DOCUMENT RESUME

ED 187 239 HE 012 708

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TITLE An Evaluation Model for State of the Art Programs for Engineering Practitioners.
INSTITUTION California Univ., Berkeley. Extension Div.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Mar 80
GRANT SED-78-22138
NOTE 234p.

EDRS PRICE MF01/PC10 Plus Postage.
DESCRIPTORS Course Evaluation; Course Objectives; Data Bases; *Engineering Education; *Engineers; Interviews; *Minicourses; Models; Participant Satisfaction; Pilot Projects; *Professional Continuing Education; *Program Effectiveness; Questionnaires; *Refresher Courses; Student Characteristics; Student Evaluation; Student Evaluation of Teacher Performance; Student Motivation

ABSTRACT

A pilot-model for evaluating state-of-the-art short-courses for engineer practitioners was developed based on assessments of 10 Continuing Education in Engineering (CEE) courses offered by University Extension of the University of California, Berkeley. Instruments used in the study included student questionnaires, faculty interviews, follow-up questionnaires and interviews with participants, interviews with supervisers and colleagues and observations of classes. Program characteristics, demographic and attitudinal participant characteristics, and work demand and conditions were examined. Part One, Procedures, examines course characteristics, design of study, questionnaires, evaluation procedures, and interviews. Part Two, Results, examines developing a data base, students' rating by course, student profiles, experience vs. attitude toward the course, course expectations, and student characteristics. The final sections offer a summary of findings such as: student diversity poses a major dilemma for faculty members who plan to teach CEE short-courses; participants were generally satisfied with the CEE courses they took; and participants were interested in taking further courses in the subject. A discussion section offers general information on aspects of planning, teaching, and evaluating a CEE short-course and provides a taxonomy of educational outcomes. References are provided. Appendices include: instruments used in the study; example of a data base; and evaluation reports on individual CEE courses. (LC)

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AN EVALUATION MODEL FOR STATE OF THE ART PROGRAMS FOR ENGINEER PRACTITIONERS

MARCH, 1980

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HE 012 208

ABSTRACT

Maxwell, Martha. An Evaluation Model for State of the Art Programs for Engineer Practitioners. (NSF Grant # SED -78-22138), University Extension, University of California at Berkeley, March 1980.

An pilot-model for evaluating state of the art short-courses for engineer practitioners was developed based on assessments of 10 Continuing Education in Engineering courses offered by University Extension at the University of California, Berkeley. The instruments used included student questionnaires, faculty interviews, follow-up questionnaires and interviews with participants, interviews with supervisers and colleagues and observations of classes. A sample data base, a taxonomy of educational outcomes, and suggestions for improving CEE courses are described.

ACKNOWLEDGEMENTS

The advice and support of Dr. John Shremp and Professor Charles Susskind of the University of California Berkeley were invaluable in getting the project underway and the cooperation of the staff of the Engineering Department of University Extension has been essential in completing the study.

Very special thanks are due to the faculty-members-in-charge of the ten CEE courses we evaluated. Without their support and cooperation, the study would have been impossible.

Martha Maxwell
Project Director

AN EVALUATION MODEL FOR STATE OF THE ART PROGRAMS FOR ENGINEER PRACTITIONERS

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The material in this report is based upon work partially supported by the National Science Foundation under Grant No. SED79-22138. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the author and do not necessarily reflect the views of the National Science Foundation.

MARCH, 1980

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The purpose of this project was to develop a "pilot-model" for evaluating the effectiveness of state-of-the-art short courses in Continuing Education for Engineers (CEE). Specifically, we attempted to identify and document evidence of participants' learning and transfer of new information, concepts, and technology taught in CEE programs and identify the variables that appear to enhance or impede application of the skills and information learned. Among the variable studies were: (1) program characteristics (including organization, content, teaching strategies, etc.); (2) demographic and attitudinal participant characteristics (experience in course specialty, academic preparation, expectations, attitudes toward course, etc.) and (3) work demand and conditions (data on work context from participants, colleagues and supervisor.)

State of the art CEE short-courses are operationally defined in this study as brief, intensive programs that focus on highly specialized topics, that are usally taught by instructional teams (including both engineering faculty and representatives from industry,) and that emphasize new developments in theory, research, and technology. State-of-the art shor-courses are distinguished from review or refresher courses designed to help engineers prepare for Board examinations or those offered to students seeking college degrees. Although there is some content overlap between state-of-the-art short-courses and other CEE courses, we view state-of-the-art courses as being more clearly focused on a relatively narrow, but highly significant topic. They are not seminars among peers as are many programs offered by professional associations, but are rather courses in which instructors translate new information in "bit-sized" pieces for engineer practitioners who are not as sophisticated about the topic as are lecturers.

Because of their nature, state of the art courses may have restricted audiences, small enrollments, and or may attract engineers from distant geographical areas.

The project produced a pilot-model for evaluating the effectiveness of CEE state-of-the-art short-courses and set of suggestions for program directors and instructors to use as a guide for planning and improving CEE courses.

PROCEDURES

To implement the project goal, an intensive review of the literature and a study of CEE short-courses and their participants were completed. Twelve sections of ten different short courses offered by the University of California, Berkeley Extension Department and the College of Engineering in 1978 and 1979 were evaluated using the following procedures: 1) faculty members were interviewed prior the beginning of the course or contacted by mail; 2) a student evaluation questionnaire was tailored the the special needs of the course and approved by the faculty member in charge; 3) student evaluation questionnaires were administered to students during the last day of the course and/or sent to them after the course ended; 4) observations of the class sessions were made by the evaluation team; and 5) case studies based on follow-up interviews with participants who volunteered, and, in some cases, their colleagues and administrators were produced.

The ten short courses chosen for the study are typical of the wide range of courses offered by the University of California, Berkely Extension's Engineering Department during the period covered by the grant. These courses differed in many ways--in length (from one to five days),

TABLE 1
COURSE CHARACTERISTICS

Course Title & Description	Prerequisites	Teaching Methods	Length	No. of Speakers	Materials
Interfacing to a Microcomputer: Overview to input/output interfacing techniques & hardware/software tradeoffs in using microcomputers.	Background in engineering or science. Some knowledge of programming	Lectures plus workshop-daily lab. Practice on 6 experiments.	5 days	2 and 2 lab assts.	yes manuals
Computer Aids for IC Technology and Device Design: Current problems in IC processing, update on Stanford research, & advances in process modeling.	None Stated	Lectures, a/v aids including videotape.	1 day	13	Yes- background material, (Lecture notes as advertised were not available.)
Exponential Smoothing and Adaptive Forecasting Techniques: Designing & applying simple & useful forecasting procedures for engrs. & businessmen.	Some familiarity with basic statistical concepts	Lectures, question & answer session	1 day	1	yes
Value Engineered Design & Construction: How to accomplish design & construction saving using the value engineering management system.	None stated	Lectures, films, team workshops discussing real-life projects.	5 days	2	Yes-books & materials sent in advance of course.
Composite Materials Computation Workshop: A Practical Guide to Design and Testing: The most current guide to solving problems in composites design & testing for users & producers.	Operational knowledge of TI-569	Lectures, drills, 2 informal 2-hr. workshop sessions each evening.	5 days	4	Yes-students given methods charts, & pre-programmed equations for calculators & handbooks.

TABLE 1
COURSE CHARACTERISTICS
(Continued)

Course Title & Description	Prerequisites	Teaching Methods	Length	No. of Speakers	Materials
Fundamentals of High-Resolution Lithography: A conceptual foundation for 3 types of Lithography-Deep UV, E-Beam, & x-ray, resist materials, compatible processes, & process modeling tools, & a user-oriented simulator for-project or printing.	None stated	Lectures, question & answer. Panel at end, a/v aids.	1 day	4	Yes, (Notes & some viewgraphs.
Electron-Beam Lithography: Advantages & disadvantages of electron-beam fabrication for high performance integrated electronic circuits.	None stated	Lectures, question & answer. Panel at end, a/v aids.	1 day	4	Yes
Airport Systems Planning & Design: Air travel demand forcasting, site selection-capacity; airfield design passenger processing, financial planning, & current legislation.	None stated	Lectures, a/v aids, discussion session.	4 days	14	Yes
Engineering Design in Timber: The technology of designing structures in timber.	General knowledge of structural theory & design.	Lectures, a/v aids.	3½ days	4	Handouts
Earthquake Analysis of Multi-story Fram & Shearwall Buildings: Describes 4 computer codes for earthquake analyses & their practical applications.	Some experience with computer applications for structural design & fundamental building analysis.	Lectures, question & answer session	2 days	6	Yes, input manuals, explanations or each code & examples.

in subject area (from high resolution lithography to airport systems in instructional format (lectures to intensive workshops), and in size (from 12 to more than 300 students). (See Table 1 Course Characteristics.)

DESIGN

Fig. 1* outlines the general evaluation plan and lists the major course aspects addressed in the left column: program objectives, instructional methodology, program context, student outcomes, overall effectiveness, side effects and cost factors. The instruments are given at the top of the chart with an X indicating which methods were used to measure each concern. The instruments included:

1. Systematic expert judgment-decisions made by the faculty sponsor; the CEE coordinator and the instructors in designing and planning the program.
2. Student evaluation questionnaire-administered to all participants at the end of each program.
3. Instructor evaluation interviews-conducted with instructors prior to and, in some cases, after the course.
4. Observations of course-the investigators observed some of the sessions of each program when possible.
5. Follow-up Survey Questionnaires-mailed to students after the course was completed.
6. Interview with Students-volunteers were contacted by phone and interviews arranged after the course ended.
7. Interviews with Administrators-arranged by phone with participant consent.

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*This plan is a modified version of evaluation methods described by Scriven (1974) and Anderson and Ball (1978).

FIGURE 1
DESIGN OF STUDY

PURPOSES PROGRAM OBJECTIVES	Systematic expert judgment (faculty sponsor, CEE Comm.)	Student Evaluation questionnaire	Interviews with Instructors	Observation of course	Follow-up survey of students	Interviews with students	Interviews with supervisors
Validity & utility in meeting student needs	X	X	X	X	X	X	X
Professional acceptance	X						X
Student acceptance		X		X	X	X	
PROGRAM CONTENT							
Relevance to program objectives	X		X	X	X	X	
Coverage of objectives	X	X	X	X	X	X	
Technical Accuracy	X	X			X	X	
Degree of Structure	X	X		X	X	X	
Relevance to backgrounds of Students	X	X	X	X	X	X	
Effectiveness of components	X	X	X	X	X	X	
Sequencing of components	X	X	X	X	X	X	
Difficulty	X	X	X	X	X	X	
Student acceptance		X	X	X	X	X	
INSTRUCTIONAL METHODOLOGY							
Effectiveness of presentation methods	X	X	X	X	X	X	
Pacing & Length	X	X	X	X	X	X	
Opportunity for students to question/ interact with instructors	X	X	X	X	X	X	
Effectiveness of A/V aids	X	X		X	X	X	

Figure 1 Continued

	Systematic expert judgment (faculty sponsor, CEE coordinators	Student Evaluation Questionnaire (end of course)	Interviews with Instructors	Observation of course	Follow-up survey of students	Interviews with students	Interviews with supervisors
Effectiveness of handouts, prepared notes, assigned reading materials	X	X		X	X	X	
PROGRAM CONTEXT Administrative structure, auspices	X		X				
Program administration procedures	X		X	X			
Staff roles & Relationships	X		X	X			
Public Relations efforts	X	X			X	X	X
Facilities (room, space etc.)		X	X	X	X	X	
STUDENT OUTCOMES Application of course content to job					X	X	X
Dissemination of course information to other professionals					X	X	X
Impact of course on professional growth & development					X	X	X
OVERALL EFFECTIVENESS IN MEETING STUDENT NEEDS Short-term		X			X	X	X
Long-term		X			X	X	X
MINIMAL NEGATIVE SIDE-EFFECTS					X	X	X
IMPORTANT POSITIVE SIDE-EFFECTS					X	X	X
COST In relation to alternative strategies oriented toward same need	X	X			X	X	X
Cost in Relation to Benefits	X				X	X	X

QUESTIONNAIRES

Each class was surveyed either at the conclusion of the session or after the course had ended through follow-up questionnaires. Whether end-of-course or follow-up surveys were used was determined by the instructor for in one-day courses there was rarely enough time to administer questionnaires

The student evaluation questionnaires were designed to measure the following variables: 1) demographic characteristics of the student/participants, 2) satisfaction with attitudes toward various aspects of the course (e.g. comparision with other CEE courses, whether the course fulfilled expectations, etc.,) 3) suggestions for improving the course, 4) relevance of course materials and content to engineers' needs, and 5) impact of the course and how information and methods learned in the course were or could be used on the job. (NOTE; questions may be found in Appendix A) Complete questionnaires are in Appendix C.

Questions were tailored to the individual course and, therefore, varied somewhat from course to course. Each course questionnaire was reviewed by the faculty coordinator and revised as necessary before administering it to the participants.

Questionnaires were given at the end of the course to six classes and student in four classes were sent follow-up questionnaires at periods ranging from two weeks to one year after the course was completed. (see Table 2 for the evaluation procedures used in different classes.)

Responses to the questionnaires were coded, punched on IBM cards, and analyzed on the IBM 6400 Computer using the Statistical Package for the Social Sciences (SPSS) developed at the Vogelback Computing Center at

TABLE 2
EVALUATION PROCEDURES

COURSE	NUMBER ENROLLED	INSTRUCTOR INTERVIEWED	SURVEY OF STUDENTS END OF CLASS (#)	SURVEY OF STUDENTS FOLLOW-UP (#)	OBSERVATION OF OF CLASS	STUDENTS INTERVIEWED (#)
Interfacing to a Microcomputer	12	yes	yes (12)	no	yes	yes (4)[1]
Computer Aids for IC Technology	305	yes	no	yes (52)[2]	yes	yes (5)[1]
Forecasting Techniques	36	yes	no	yes (19)	yes	yes (2)
Value Engineering						
(1978 Class)	11	yes	no	yes (8)	no	yes (3)
(1979 Class)	17	yes	yes (17)	no	yes	yes (4)
Composite Materials Computation Workshop	65	no	no	yes (35)	no	yes (7)
Fundamentals of High Resolution Lithography	132	yes	yes (90)	no	yes	yes (20)
E-Beam Lithography	108	no	no	yes (54)	no	yes (7)[1]
Airport Systems						
(1978 Class)	48	yes	no	yes (27)	no	no
(1979 Class)	46	yes	yes (32)	no	yes	yes (9)
Engr. Design in Timber	28	yes	yes (28)	no	yes	yes (9)
Earthquake Analysis	50	yes	yes (49)	no	yes	yes (11)[1]

Number of students replying to survey questions = 423
Number of follow-up interviews with students = 81

1. Administrators/colleagues interviewed (total=5)
2. Questionnaires were sent to a random sample of 100 students; 52 replied

Northwestern University.

Participants volunteered to be interviewed for the project by including their names and phone numbers on the end of the questionnare. (See Appendix A for the statment describing the project and the interview invitation.)

INTERVIEWS

Participants who were willing to be interviewed or wanted more information about the study were called by a project team member, and interviews were arranged. In most cases, participants requested phone interviews.

The questions asked by the interviewer were designed to encourage students to elaborate on and clarify their questionnaire responses, to describe whether and how they had applied course information to their work, and to describe the context of their work environment and its impact on transfer. (The Interview Protocol is included in Appendix A.) Interviewers also asked participants for permission to interview their supervisers and colleagues.

Faculty Interviews In most courses it was possible for a member of the project to interview the faculty members before the course began. In other instances, the faculty member was contacted during or after the course, and queried about the course goals, the instructor's expectations, etc. (The faculty interview protocol is included in Appendix A.)

Interviews with Supervisers and Colleagues. If the participant agreed, the project team member contacted the superviser and/or colleagues mentioned by the interviewee. The protocol for these interviews is found in Appendix A.

Analysis of Interview Data. Interview responses of participants, colleagues, and supervisers were recorded, summarized for the individual course evaluation reports (See Appendix C), coded for the computer analysis, and used to write brief case studies.

Faculty interview data were recorded and summarized in the individual course evaluations and used in interpreting the results of this project.

Class Observations

A project team member attended the CEE classes, recorded impressions, and talked with students when this was feasible (See Table 2). These observations were incorporated in the individual course evaluations found in Appendix C and aided us to refining the questionnaires and interview protocols and in interpreting results.

RESULTS

Of the 653 students from 12 classes who received course evaluation questionnaires, 423 replied. As might be expected, the response rate was higher when questionnaires were given out during the class (80%) than when they were sent by mail (52%). We tried to increase the return rate of mailed questionnaires by following the suggestions of Ohrlich in Designing Sensible Surveys, 1978 (p.94)-that is, a follow-up postcard was sent within one week; a second copy of the survey and cover letter was sent within two weeks; and a third instrument was sent within one month. However, when this intensive follow-up was used on two classes (E-Beam Lithography and Workshop on Composite Materials), the response rate did not significently excede that of courses where participants were not contacted repeatedly, and the small number of additional responses obtained did not seem to warrant the high mailing costs. Therefore, we decided to send only one follow-up - a cover letter and second copy of the questionnaire.

Although the response rate was higher for questionnaires given out in class, these participants tended to reply to the questions more superficially and leave more items blank than did students who returned follow-up questionnaires by mail. 119 respondents indicated they were willing to be interviewed and 81 were interviewed by a member of the project

team. A number of factors mitigated against interviewing all of those who were willing to participate - sometimes it was not possible to contact the students. Sometimes they changed their minds about being interviewed. Others were too busy - or had changed fields, and in some cases, we felt that we had interviewed enough students from a course to sample the range of opinions in the class.

From computer analysis of questionnaire data we prepared evaluation reports on each course. (See Appendix C). We compared courses, and developed a model data base useful for assessing new courses and making other kinds of administrative and instructional decisions (See Appendix B.) In addition, we analyzed the profiles of students with different characteristics.

Developing a Data Base. A Sample data base was compiled by summing the responses of participants to the written survey and interview questions and computing percentages. (See Appendix A.) Such a data base could be of great value in aiding administrators in making decisions and in helping new instructors form realistic expectations about CEE courses, if kept systematically over a longer time-span. A systematic data base provides a standard for identifying successful courses and analyzing their characteristics, and for assessing the effectiveness of new courses and the improvements made in old ones. Courses that are not working well can be identified and the reasons explored. Also, these data reveal differences in the effectiveness of different courses or repeated offerings of the same course.

New instructors might find data base information valuable in planning courses for example the fact that one-third of the engineers in CEE classes have taken no previous CEE courses, or that on the average about a quarter of the students have had no experience in the specialty addressed by the course or that only 60% find ideas that they can use immediately and the majority are mainly interested in one third of the material presented. It might also be helpful to know that about 6 percent of the students rate the course worse than other CEE courses they have taken.

Ideally, a cumulative data base would be developed for each course because the participants in different CEE courses vary greatly in their characteristics and responses. To illustrate how this might work, consider the finding shown in Table 3 which shows how participants in different courses responded to the question, "How did this course compare with other CEE courses you have taken?"

Table 3

Students' Ratings by Course

COURSE	1	2	3	4	5	6	7	8	9	10	TOTAL
Percent of students rating it in comparison with other CEE courses taken											
Best I have taken	8%	NA	0	12%	14%	5%	4%	5%	18%	4%	6
Better than others	50	NA	18	44	30	24	30	10	4	25	30
About the same as others	0	NA	17	28	30	12	31	24	35	38	25
Worse than others	0	NA	18	4	0	2	9	8	25	13	6
Have taken no others	42	NA	47	12	26	57	26	23	18	20	33

Code for courses:

1= Interfacing to a Microcomputer
2= Computer Aids for IC Tech.
3= Forecasting Techniques
4= Value Engineering
5= Composite Materials
6= Fundamentals of High Resolution Litho.
7= E-Beam Litho.
8= Airport Systems & Design
9= Timber Design
10= Earthquake Analysis

More participants gave higher ratings to the courses in microcomputing, composite materials, value engineering, and airport systems, than to other courses. Each of the preferred courses lasted a week and with the exception of the airport course, involved hands-on lab. work or participation on teams to solve real-life problem. Also, these courses were smaller in size (less than 50 students) than some of the others. Students in Timber Design and Forecasting

Techniques rated these courses lower than did participants in other courses, signaling that there were problems. The Forecasting course was a one-day course attended by a very wide range of students -- i.e., from beginners to sophisticated computer science graduate students -- and the professor had a most difficult time teaching to such a diverse group. (See report in Appendix C.) In this case, raising the stated prerequistes from "a general understanding of basic statistics" to something higher and altering the instructional strategies used would improve the course for both the professor and the students.

The Timber Course, which was offered for the first time, attracted students who had taken previous CEE courses but were new to this specialty, (40%) and engineers complained that the course was too theoretical. Handouts but not course notes were given out and a number of students objected to not receiving notes.

Differences between courses in the percentage of students who have not taken previous CEE courses are also apparent in Table 3. Interfacing to a Microcomputer, Forecasting Techniques, and Fundamentals of High Resolution Lithography attracted higher percentages of students new to CEE, than did the other courses. Perhaps this resulted from the newness of the subject matter covered and in the case of High Resolution Lithography the course title "Fundamentals" attracted a number of students who wanted a beginning course. (See discussion in App. C.)

Table 4 illustrates another way to use questionnaire data from individual courses to show the relationship between variables.

TABLE 4

Relation Between the % of Engineers with
Minimal Experience in the Specialty and
Complaints about Instructors' Emphasis on Applications

Course	1	2	3	4	5	6	7	8	9	10
% of participants with less than 1 yr's. experience in specialty	50%	NA	10%	12%	42%	27%	29%	29%	40%	26%
% of participants stating that instructors placed too little emphasis on applications	NA	NA	57	14	61	NA	27	29	53	30

Code for courses:

1 = Interfacing to a Microcomputer
2 = Computer Aids for IC Tech
3 = Forecasting Techniques
4 = Value Engineering
5 = Composite Material
6 = Fundamentals of High Resolution Litho
7 = E-Beam Litho.
8 = Airport Systems
9 = Timber Design
10 = Earthquake Analysis

The percentages in Table 4 suggest a relationship between the number of inexperienced participants enrolled in a class and complaints that the instructors did not place enough emphasis on applications. In both the Composites Materials and Timber courses there were a high percentage of newcomers to the specialty, and over half the class felt there was too little emphasis on applications. (See Appendix A and the Discussion Section) In the Forecasting course, although most of the students had practical experience in the field, only a few had formal courses and it was to these advanced students that the professor directed his presentation. As a result both advanced and beginning students were turned off.

(See Appendix C.) In the Microcomputer course most of the students, despite having little experience with this particular device, did have experience with computer programming in general. Although the question about instructors' emphasis on applications was not asked and most students were favorable toward the course, a number complained that there was too much emphasis on hardware.

Evaluating CEE courses as different in content and emphasis as these courses were which attract such diverse student is difficult indeed. The many variable involved (student characteristics, type of course, length and size of class, instructors' style and level, etc.) all interact. However, a data base can provide the program planner with a barometer to measure the relative/success of different classes. Both the strongest and weakest courses can be identified and their characteristics analyzed and studied, so that models of successful courses can be developed and ameliorative steps can be taken to strengthen weak programs.

Student Profiles. In addition to showing us overall characteristic s of CEE students and comparing courses, the SPSS data analysis program enabled us to develop profiles of students. These profiles yield a partial answer to questions about the characteristics of CEE students. For example, we were interested in the fact that a number of engineers with little or no experience in the topic enrolled in very specialized CEE courses and wondered why? Were they merely curious? Were they contemplating changing careers? Were they new graduates just embarking on an engineering career? To find out, we analyzed profiles of the responses of students with varying levels of experience in the course topics.

EXPERIENCE VS ATTITUDE TOWARD COURSE (PROFILE)

One suprising fact that emerged from the data analysis was that 72 percent of the participants who had little or no experience in the course specialty had completed their degrees more than 14 years ago. 92% of those new to the field had held engineering degrees for more than 4 years. This suggests that some had made mid-career changes or were contemplating doing so or had some other reason to be interested in the course. For example, one was a company president who was trying to keep abeast of new developments in one of his departments, another a structural engineer curious about whether computer programs in earthquake analysis might have implications for his work in designing stacks to withstand wind factors. Another was a consultant, trained in a different specialty, but convinced that he could save money by taking the course himself rather than hiring a consultant and improve his advice to his clients.

The data analysis revealed some significant differences between participants with little experience in the course content and those with more experience. The inexperienced group were more likely to hold Ph.D. degrees, spend less than 30% of their time on administrative duties and more than 70% of their working time in technical tasks, primarily in research and development units. The average inexperienced participant rated the course as meeting his goals in updating information, learning fundamentals, acquiring a perspective for decision-making as "somewhat successful," but felt it improved his general background "very well". 84% had no previous courses in the field compared with 46% of the more experienced engineers. Furthermore, the inexperienced group showed less interest in taking other CEE courses, and were not planning to do research on their own.

They complained more frequently about course materials as well as most other aspects of the course. They felt instructors did not place enough emphasis on application , nor understand engineers needs. 75% of the group with little experience felt unprepared for the course compared with 33% of the more experienced engineers. A larger percentage of the inexperienced group (60%) said they found nothing in the course that they could use immediately compared with 40% of the experienced group. Inexperienced participants were more likely to feel they might be able to use the course information in the future.

In summary, the inexperienced group tended to be highly educated but unprepared for this course, complained about the instructor's not emphasizing applications, the materials, and other aspects of the course, and found little they could use immediately. They were also less likely to volunteer for interviews than the more experienced group.

Another question we examined was expectations for the course since this question is often used to assess attitudes toward a course.

COURSE EXPECTATIONS

The profiles of engineers who said that the course did not meet their expectations differed from those whose expectations were met. The former group were:

--more likely to hold a Bachelor's degree than a Ph.D., to work primarily on technical tasks, and to have had more than 10 year's experience in the field.

--more likely to have enrolled in the Forecasting Airport Systems and I.C. Technology courses than the other courses.

--more likely to have taken previous CEE courses and more likely to rate this course as "worse," "better," or "best" in comparison with other courses they had taken. (Fewer ranked it as "the same" as other courses.)

--less likely to find topics that they could use immediately or in the future and were general less satisfied that the course met their goals of updating, learning fundamentals, and solving problems.

--gave more suggestions for improving the course especially about instructors and content and expressed more negative evaluations of instructors. They tended to criticize instructors for not placing enough emphasis on applications (74%), not focusing on engineers' interests, not placing enough or placing too much emphasis on fundamentals.

--they were more likely to discuss the course with their colleagues but less likely to recommend this course to their peers.

--they agreed that the course had helped them professionally in about the same proportions as those whose expectations were met.

In summary, the data base can be used to determine characteristics of engineers who enroll in CEE courses, to determined differences between classes, and to make profiles of satisfied and dissatisfied students.

Characteristics of Students Who Were Interviewed

Twenty-two percent of the students who completed written questionnaires were willing to be interviewed for the study and 68 percent (81 engineers) were interviewed.

We compared the questionnaire responses of engineers who volunteered to be interviewed with those who did not to see whether the two groups differed. We found that those who were willing to be interviewed were more involved and concerned about the course and had stronger opinions (both positive and negative) than those who did not volunteer. That is, they more often rated the course as meeting their goals "very well" or "not at all" and less frequently checked "somewhat." Compared to the group that was not willing to be interviewed, more held Bachelors or Masters degrees and fewer had P h.D.s. Fewer had taken previous CEE courses and they made more suggestions about improving course materials. They also were more likely to have expected something different than the course offered. However, some were dissatisfied with the results of the course and others were pleasantly surprised. They also expressed a greater interest in taking future CEE courses than those who were not interviewed.

Interviews with Administrators.

Five administrators who supervised course participants were interviewed about the effects of the course on the engineer's work. In general, these supervisors had positive things to say about the U.C.B. CEE courses, but little specific information about how the information learned had been applied. Their comments were included in some of the short case studies incorporated in the reports in Appendix C and in the Discussion Section.

2. Student Satisfaction.

Generally, participants were satisfied with the CEE courses they took. Seventy-five percent took the courses to update their knowledge of the specialty, and 55 percent of these were well satisfied. More than half of those who had taken previous CEE courses rated their present course as better than other courses they had taken.

In general, engineers rated the intensive one-week hands-on lab. or problem solving courses higher than the large one-day lecture/demonstration courses.

Those whose goals were learning fundamentals, acquiring a perspective for decision-making, solving special problems, etc. were somewhat less satisfied with the courses than those specifically interested in updating information, but even so, the average participant was satisfied.

3. Interest in Taking Further CEE Courses.

One consistent finding across courses was that participants were interested in taking further courses in the subject. Completing a CEE course seems to arouse an interest in learning more about a topic and pursuing it more deeply. Consistent with the finding of other studies in continuing education, the practicing engineer who takes a CEE course develops a greater awareness of the subject and a desire to learn more. However, his/her options for further CEE courses are limited at U.C. Berkeley. There is a great need for more intensive courses in all specialties offered-a need that is not being met by present courses. Taking a CEE course seems to whet the student's appetite for more learning, but at present, there are few relevant courses offered. Many of the participants in current courses would be willing to spend an extra day if they could get

SUMMARY OF FINDINGS

The constraints and limitations of the design and sample used in this study suggest caution be used in generalizing the following findings:

1. Student Diversity

Engineers and others who enroll in the University of California, Berkeley CEE short-courses vary widely in educational background, experience, need, expectations, and their reasons for taking the course. They range from the merely curious to the college professor: from those who are just entering the specialty to researchers whose experiments are contributing to new knowledge. Three-fourths of the participants, in the typical course, have not taken a previous course in the specialty, although about two-thirds have taken other CEE short-courses. About a quarter of the participants in the average class are new to the field, but almost half of the participants in some classes have little or no experience in the specialty addressed by the course. Participants show a wide range of interests. Usually they are mainly concerned with a third of the topics covered in the course. Student diversity poses a major dilemna for the faculty members who plan and teach CEE short-courses.

On the other hand, short-course participants share some things in common. They are generally well-educated, motivated to learn, and interested in the course. In almost all cases their companies pay their course fees and expenses and the majority of students are self-selected.

an intensive workshop or a lab. that would help them learn how to apply the computer programs described or whatever the course covered. The desire for additional courses was equally strong among engineers taking one-week short-courses as those attending one-day programs.

IMPACT OF THE COURSE

The effects of the course on students were as varied as the students themselves. About 60% found something they could use immediately and 55% found something they felt would be of future value (as if they were tucking ideas away in their intellectual hope chests). . .

The follow-up revealed that some had applied the ideas and techniques learned in the course directly to their work while others had not thought about it since the course ended. Whether an engineer used course information depended on his work environment, specifically whether he had the power to change things or try new ideas and approaches and whether he was presently involved in projects that were relevant to the course content. Also application seemed to depend on the nature of the course. For example, the Value Engineering course participants in most cases felt the information they learned was very useful in their own day-to-day work regardless of whether the company accepted the VE package and regardless of what their work colleagues were doing.

Whether a course was considered practical also was contingent on the work setting. For example, one engineer considered a topic so futuristic as to be classed as science fiction relative to his company while another member of the same class went back to his lab., built an instrument, replicated one of the experiments described in the course, and proceded to determine whether it would improve his company's product.

The time between taking the course and being interviewed made a difference. Figures, facts, and faces fade fast but feelings about the course linger on. Most remembered the course as a good experience, though a few felt frustrated. Some who rated the course "about the same as others I have taken" at the end seemed to mellow when they discussed it a few weeks later. Their first reaction to the course, they said, was based on the last speaker who did not tell them anything new. Several weeks later, they were more positive about it since they could see it in perspective. This suggests that end-of-class questionnaires may not have the reliability expected and other strategies should be used as well.

Recollection of the topics presented in the course after several months depended on whether the participant had taken subsequent CEE courses. If they had, they were likely to recall less about the particular course we were interested in and confuse the courses.

INTERESTS IN OTHER COURSES

Forty-five percent of the participants listed other courses that they would be interested in taking while 72% checked that they planned to take further courses. An even higher percentage (77%) indicated that they planned to do further research on course topics on their own time.

The average participant (61%) found something in the course that could be used immediately while more than half (55%) said they felt they learned information that they could use in the future.

Ripple Effect Almost all of the participants said they planned to talk about the course with their colleagues (97%) and with their supervisors (96%). We did not ask how many planned to discuss course information with their subordinates, but perhaps we should have.

The follow-up interviews revealed that participants did spread the information learned in the course to others in their companies in a variety of ways - the most frequent was through memos, meeting, passing course materials around, holding brainstorming sessions, etc. It is clear that ideas and technology learned in the CEE courses are transmitted by participants to others in their companies. The number of non-students reached depends on how many interested specialists are in the participant's department.

Typically, participants indicated that they expected to use the course materials regularly (54%), though 37% said "maybe" and 10% doubted it. Responses to this question, as is true of other questions, varied considerably from courses to course.

On the whole, participants felt strongly that taking the CEE course would help them professionally (79%), however they were not as sure about the value of their taking the course to their companies. Sixty-four percent felt it "maybe" of value to their company, with only 29% responding with a definite yes. Again those engineers enrolled in courses like Value Engineering were more positive. For example, some reported that if they became certified as V.E.'s their company could qualify for government grants.

Does taking a CEE course improve an engineer's chances for promotion?

We asked five classes "How does your company recognize attendance at courses like this one?" Very few (between zero and 8%) of the participants checked the alternative "Course attendance increases the possibility of promotion/raises." It appears that either few engineers view attendance at CEE courses as a way of moving up in their companies or they are modest about their intentions in taking the course. In a large follow-back study of CEE students, Morris (1978) concluded that engineers

who enrolled regulary in CEE courses increased their earnings over those who did not. We did not address this question directly as our design did not include a control group. One factor that could influence earnings is that CEE participants are usually self-selected, and it may be that better qualified people seek out courses and promotion follows.

SOURCES OF DISCONTENT

Course Title and Descriptions

More dollars, time, effort, and creativity seem to be invested in the artwork and layout of the course brochure than are spent in devising the course title and writing the course description. CEE course titles, like their academic counterparts, once approved, seem to be engraved in stone. They are rarely changed despite changes in instructors, content, and emphasis. Engineers tend to interpret these literally. First-timers in CEE courses complained that in some cases the course titles and descriptions were misleading. For example, students who took Fundamentals of High Resolution Lithography for an overview of current developments in the field tended to be well satisfied while those who enrolled to get the the basic fundamentals of a field new to them were less satisfied with the course. Of course, the term "Fundamentals" is relative--what is considered fundamental to a Berkeley engineering professor might be viewed as very advanced to a practicing engineer.

In courses with double titles such as Computer Aids for IC Technology and Device Design or Airport Planning and Design, engineers expected equal time and emphasis would be placed on both topics. In these instances, the device designers and the airport designers felt their areas had been slighted in the instructors presentations. It may be necessary for Extension programs to be broad in scope and cover more than one specialty in order to insure that courses fill or it may be that the faculty members feel that closely related specialties should be covered in one course, but, if this is true, participants did not seem to understand the reasons.

Course descriptions also came under fire by some participants. One intensive five-day workshop advertised as "explicity application oriented" drew complaints from 56% of the class

that the instructors did not place enough emphasis on applications. Clearly here there was a difference between the instructors' perceptions of "application" and the students' perceptions. In other courses, students complained that discussion groups described in the course announcement were not held or that the actual course differed in significant ways from the brochure statements. Very few of the CEE courses we evaluated listed prerequistes or described the level of the course presentations, and in some cases, the instructors overestimated the sophistication and knowledge of their classes. Although CEE courses can't deny access to students, a clear description of the background knowledge expected by the instructor whould help the students put the course in proper perspective. These examples suggest that course titles and descriptions should be more closely monitored by CEE director who could provide faculty with information on how to avoid these difficulties, and write more accurate titles and descriptions.

COURSE MATERIALS

Engineers who take CEE courses expect to receive clear, complete lecture outlines and other relevant materials. Indeed a number of participants enroll in CEE courses primarily for the materials. Complaints about inadequate or poorly prepared materials are the most frequent criticism raised by students. Ph.D. engineers, particularly those who are new to the specialty, are most likely to complain about the course materials, especially if they do not received good lecture outlines. They find it impossible to take adequate notes in the information-intensive, fast-paced lectures. Most of the participants pass course notes and other materials on to their company supervisers and colleagues or use them to prepare memos and presentations to their staff. Others who are currently involved in other specialties complain that when they need to review

the course information at some later date, the materials are too scanty to help them recall the course. Still others need more detail to help them on immediate projects. If students are to effectively apply new ideas and technology to their work, they need to receive outlines and good reference materials in the course. Retention of the mass of data presented in the typical short-course is impossible without notes and other materials.

Similarly, copies of the viewgraphs used in lectures are necessary. Participants roar if they don't receive copies of all the viewgraphs, but also complain if the viewgraph reproductions are inadequately labeled or out of sequence. Poor lecture notes and course materials (or the lack of them) seem to exacerbate students' feelings of discontent with the course and inhibit learning.

Many engineers would find it very helpful if course materials were sent in advance. They say that getting materials ahead of time would enable them to be better prepared and ask more relevant questions.

Sending out materials in advance can be time-consuming and expensive, but we found that when instructors did this, participants were better satisfied with the course. At a minimum, instructors could include a few references in the course announcement for those engineers who are motivated to review and prepare themselves for the course.

DISCUSSION

Evaluation Realities and Difficulties Berkeley Extension routinely encourages CEE instructors to give student evaluation forms to each class, but like other extension departments, it lacks the resources and dollars to perform long-term follow-up studies that might yield information about the pay-off of its courses to companies and individuals. Since extension courses are expected to pay for themselves, there are limited resources for assessing and describing the characteristics of the students who attend and for assessing the needs and expectations of industries and agencies who send engineers to the programs, or for determing the formal and informal effects of the programs. Books on educational evaluation range from textbooks to encyclopedias to do-it-yourself kits. Works by Anderson and Others, 1975; Ball and Anderson, 1979; Bloom and Others, 1971; Center, 1979; Dressel, 1976; Morris, 1978; Popham, 1973; 1974, 1975; Scriven, 1974, 1967, 1973; Streuning and Guttentag, 1975; and Webb and Sechrest, 1966 illustrate a few of the more influential approaches to educational evaluation.

Extension programs are not exempt from the pressure to evaluate and currently books are appearing on how to assess the impact of continuing education courses (Preston and Others, 1979; Knox, 1979-c & d.) Undoubtedly as budgets tighten and the economy worsens, there will be increasing pressure to demonstrate the value of programs. . . and less money to do it with.

But how widespread is systematic program evaluation in post-secondary education? In a survey of practices in program evaluation, Ball and Anderson (1975) examined some 200 educational programs divided equally among the Department of Defense, other federal government departments and agencies,

TAXONOMY OF EDUCATIONAL OUTCOMES

Educational Development	Evidence: Level 1	Level 2
1. Updates information/increase awareness of new developments in field. (A,B,C)		
2. Acquires new knowledge (A,B,C)	Increased desire to learn more about the field (B,D,D)	Enrolln in other CEE courses, self-study (C,D)
3. Increases general background in subject (A,B,C)	Increase receptivity to new ideas (B,C,D,E,F)	
4. Reviews fundamentals (A,B,C)		
5. Acquires perspective for decision-making (A,B,C)	Spreads information to others-supervisor, colleagues, subordinates (Ripple effect) (C,D,E,F)	Convinces others to change. (C,D,E,F)
6. Learns theory (A,B,C)		
7. Gets overview of a new field (A,B,C)		
8. Confirms previous knowledge/hunches (A,B,C)		
9. Gets ideas can use in future-(hope-chest) (A,B,C)		
Improved Morale/Sense of Efficacy		
10. Increases confidence in own abilites and skills (B,C)	Approaches work with greater confidence, zest. (C,D,E,F)	Is advanced or promoted in company or gets another job. (C,D,E,F)
11. Improves attitude toward job.. (B,C,D)	Improves productivity ((C,D,E,F)	
12. Meets and talks with other professionals (A,B,C)		

can be useful for ther purposes as well. Students do not object to answering basic demographic questions and skip fewer of them than they do attitudinal items.

Therefore, end-of-course questionnaires are an important evaluation tool - provided that they include demographic items, despite their sometimes questionable reliability and the biases they may reflect. Following up a small sample of students by phone calls or questionnaires will yield data on whether the course has helped the individual professionally and how she/he has used the information learned. Occasional phone interviews with supervisers, company development people, etc. can confirm ideas industry holds toward the courses and their perceived effects.

AN EVALUATION MODEL

The table on pages 37 and 38 is a taxonmy of educational outcomes resulting from participating in a CEE course. The left hand column shows the changes that students report they gain from completing a course. They could also be considered educational goals. There are three types of outcomes; educational development, improved morale/sense of efficacy, and improved job performance. The nine items under educational development range from "update information/increase awareness of new developments to " get ideas can use in future " and represent the kinds of knowledge acquired. The second category of outcomes are attitudinal--improved morale and an increased sense of efficacy. A sense of efficacy refers to the engineer's confidence in his own professional competence- the feeling that he knows how to do a good job, that he is qualified and productive. Efficacy is shown in increased confidence in one's ability and skills, an improved attitude toward the job, and the ability to talk with other professionals as peers.

estimated at six to seven years. That is, by seven years, half of the knowledge the engineer began with has become obselete. Futher, Saxberg states, "Theoretically in another six or seven years everything the engineer orginally knew would be obsolete. Clearly the only way for the professional to combat creeping obsolescence is to continue to move on a path of development whereby he maintains and exceeds the job demands as these increase or change over time.."

Knox (1979-e) discusses the influences on proficiency and obsolescence as follows: "Some influences on current proficiency and obsolescence reflect the individuals's previous capability and background along with his current outlook and efforts to be proficient. For example, the currently obsolete professional may never have been proficient, or may have acquired adequate knowledge but not had the minimum necessary professional experience to produce even minimal proficiency. A professional may forget information that is important to effective practice, or may experience shifts in occupational tasks that contribute to obsolescence. Some areas of proficiency are not maintained due to lack of practice. A professional's proficiency can also be affected by attitudes toward ethical aspects of practice, by efforts to interact with peers, by efforts to increase his or her proficiency in deliberate ways. by achievement motivation, and by approaches to problem solving."

Because CEE Students who are new to a specialty (even though they may have received their engineering degrees a decade or more ago) are more critical of instructors and expect to be told what to be told what to do on the job Monday morning, it is important to ask identifying demographic questions on course evaluations. This is the only way to place the complaints of dissatisfied students in context so that changes can be planned and this

analysis rather than design synthesis (Meadow, 1977.) Lack of rapport between academics and industry has been cited as a reason for low participation rates. Also the question of whether CEE courses are properly suited to the needs of adults has been raised - although it seems to make little difference since CEE courses always have and still continue to use lectures as their major teaching method. Busy engineers, like other professionals, expect lectures and few seem willing to sign up for hands-on laboratory or field experience courses . . . although those who do are very satisfied. Our point is not to discard lectures, but to improve them and add more time for participants to interact with each other and the instructors.

In our view, company training programs and on-the-job-training seem to do a good job of seeing to it that engineers learn what to do and how to do it. However, these programs rarely include the "why" and it is in this area of understanding that academic faculty can make a contribution. We found that engineers who were very experienced in a specialty were more tolerant of the college professors who used hypothetical examples and explained theory than were the newcomers to the specialty. New entrants seemed still struggling to learn the basic terms and concepts as well as how to do it and were impatient when the "why" was explained.

The problem of professional obsolescence has been a major issue in the CEE literature. (Knox, 1979-e; LeBreton, 1979; Lusterman, 1977; McDaniel and Others, 1966; Meadow , 1977; Morris, A.J., 1978; Pratt, 1979; Rothenburg 1975; Saxberg, 1979.) Saxberg writes that as engineering knowledge expands at a rapid rate, the half-life of the engineer has been

course with required prerequisities. Giuliani (1979) cites two criteria for selecting continuing education programs for impact evaluation: 1) the extent to which the duration and intensity of a program could realistically be expected to produce measurable change in participants or their organizations and 2) whether support (time, money, evaluation expertise, and faculty cooperation) for the evaluation process itself is available.

Brevity and the range of students whom they attract are two factors that combine to make evaluation of engineering short-courses particularly difficult. The engineers who attend are diverse indeed -- from the merely curious and those who are just entering the specialty to the professional with many years of experience and the researcher whose experiments are advancing the frontiers of knowledge in the specialty. Instructors usually view their goal as helping participants update their skills and knowledge in the specialty, but the variety of student needs and expectations and their different levels of sophistication pose an instructional dilemma. Teaching students who are new to the field and those who are as knowledgeable as the lecturer in the same class requires careful planning and great skill. Some instructors plan the course with something for everyone in the range; others try to keep the course at what they consider a basic level; while others aim their presentations at a hypothetical middle group somewhere between the extremes.

Because CEE courses serve so may purposes and have such a diverse student population, they are difficult to evaluate. Much of the research has criticized university-based CEE programs as not addressing the working engineer's need for job-related knowledge and too much preoccupation with

private industrial and commercial enterprises, and junior and community colleges. They found that most of the Department of Defense, other federal government programs, and private sector industrial and commercial enterprises were receiving some form of program evaluation. Most of these evaluations involved questionnaires administered to teachers and students to measure their perceptions of the program. However, it was very clear that traditional formal education institutions - the colleges - rarely indulge in program evaluation in any formal sense of the term. Ball and Anderson state unequivocally: "It seems that once a program is installed at the college level it becomes 'functionally autonomus', and it is unlikely that any formal effort will occur to gather evidence concerning the need for program modification or continuation."

Rigorous, analytical evaluation procedures are infrequently institutionalized at the college level -- even when some sort of evaluation is mandated as a part of grant funding. A survey of 375 colleges and universities that received grants for innovative instructional programs revealed that the main pattern was locally developed measures given out by individual faculty members. (Hodgkinson, Hurst, and Levine, undated.)

Evaluating continuing education programs entails the same problems that educational evaluation in general faces, including such important factors as the complexity of the process, the number of variables, the imprecision of the measures, cost, dislike of people to count results, the difficulty of interpreting results, the defensiveness of instructors and program directors, and the fact that there are few rewards for evaluation. Because tests are rarely given, there are few ways to directly measure the amount learned in CEE courses. Nor can one be sure that the students who take the courses are adequately prepared in contrast to the typical engineering

Improved Job Performance	Evidence: Level 1	Level 2
13. Solves present problems (A,B,C,D)	Initiates new projects, assumes more responsibility (C,D,E,F)	Replicates experiments, designs and implements new experiments. (C,D,E,F)
14. Improves specific job skills/ productivity (A,B,C,D,E,F)		
15. Changes procedures/viewpoint (B,C,D,E,F)	Uses new technology, ideas in work (C,D,E,F)	

Code Instruments

A = Pre-course questionnaire (for measuring goals & expectations.)
B = End-of-course Questionnaire
C = Follow-up Questionnaire
D = Follow-up Interviews with participants
E = Follow-up Interviews with supervisers
F = Follow-up Interviews with colleagues, subordinates

Response
Sample Gradient

- Basic formulations may help in my work, but I'm not sure how far I can go without further reading
- In the future, I'll be using e-beam equipment. Courses like this will help when the time comes to purchase equipment.
- Since I'm new to the field, this course gave me a good background.
- The course brought me up to date and refreshed my knowledge.
- The basic ideas from the course substantiated the knowledge I already had and reinforced my decisions to use the techniques.
- It save me at least 3 months' reading which I probably wouldn't have done.
- The course gave me new insights into management & design needs.
- Now I'm qualified to serve new clients and help my company qualify for government contracts.
- The course definitely increased my range of skills.
- The information learned will enable me to make faster decisions.

The third category "improved job performance" is self-explanatory. The engineer reports he can solve present problems, improve his skills and productivity, and change procedures. These perceived outcomes can be observed at a later time as illustrated by the items listed in the columns labeled Evidence, levels 1 and 2. For example, an individual who has increased confidence in his own skills approaches his work with greater confidence, shows improved productivity, and is promoted or advanced within his company. The letters following each item are codes for the type of instrument or method used in determing the existence of the item.
(See page 38.)

Context and Constraints

A number of factors limit the CEE student in using the information he learned in a course on his job - indeed from moving to any of the levels indicated under Evidence. As Saxberg (1979) states, "The work environment sets limits that training cannot overcome." Meadow (1977) quotes Harold Kaufman as saying that when engineers take a degree or a course at company expense but are not subsequently given more responsibility or other form of recognition, their disappointment may cause them to seek another job. Similarly, one can leave a course laden with new ideas for improving one's work, but be constrained because one lacks the power to implement change within the company. Some engineers take courses because they expect to get into a project relating to that knowledge in the future, but are presently so tied into a current project on a different topic that they have no immediate use for the knowledge they gain. Only about half of the students we interviewed were able to use the information they gained in their job.

Personal characteristics (assertiveness, ability, communication skills, etc.) also limit an engineer's ability to apply new information learned or to influence others to change.

Long range evidence of transfer of learning is thus dependent on many interrelated factors- personal characteristics of the learner, the nature of the course (including instructor's objectives, level, pace, length, materials, etc.), and opportunities for application in the work environment.

In assessing the impact of short-courses, evaluators must rely on self-report measures because achievement tests are neither used - nor are they appropriate in most CEE courses. However, questionnaires and other instruments can be improved by asking appropriate questions and by including items that identify key sub-groups (i.e., those who differ in background, experience, expectations, work opportunity to use new information, etc.) Pre-questionnaires as well as end of course and follow-up surveys should be administered to at least a sample of students. Follow-up interviews with participants, supervisers, colleagues, and/or subordinates can provide additional evidence of the course's value.

The Sample Response Gradient shown at the bottom of page 40 illustrates a way to arrange student responses concerning the course's impact so that they can be weighted as criteria by independent judges. These particular responses have been arranged so that they reflect degrees of learning, but this approach could be refined by adding more items and getting experts to weight them. Had we had a longer project, this would have been done.

RECOMMENDATIONS FOR IMPROVING CEE SHORT-COURSES

Although there are many kinds of CEE courses, we concentrated our research efforts on university extension state-of-the-art short-courses that do not give credit nor lead to a degree. U.C.B Extension classifies these courses as follows:

1. Courses aimed at updating basic, ongoing knowledge (e.g., Airport Planning and Design)or as providing basic training in a new technology (e.g., Interfacing to a Microcomputer)
2. Regulary scheduled state-of-the-art conferences (e.g., Computer Aids in IC Technology and Device Design)
3. Special one-shot topics of interest to a special population (e.g., Electron-Beam Lithography)

From the students' perspective these goals overlap so that, whatever the coordinator's intention, the same course may attract students seeking to fill each of these needs.

The recommendations that follow apply specifically to university extension courses, but may have implications for programs offered by companies and professional organizations as well.

However, university extension programs operate under special constraints that may differ from those of other providers. As appendages of universities, extension CEE programs must maintain credibility with their engineering faculty as well as with the industrial community. U.C.B. Extension's goal is to provide a high quality public service, but, at the same time, programs are expected to pay for themselves. Thus economic realities limit the kinds of programs offered and determine how often they are given. Futhermore, extension programs compete with commercial programs that don't need the approval of engineering departments and can concentrate on profit making.

U.C.B. Extension CEE courses aim at bringing faculty who work at cutting edge of new knowledge together with engineering professionals and practioners. The fact that every course is expected to be a winner and pay its own way is typical of extension programs throughout the nation. (Meadow 1977) At U.C.B. CEE course failures are few, but costly when they happen. However, some programs draw large numbers of participants enabling the department to offer a few classes that attract small audiences.

The problem of maintaining the academic standards of graduate engineering faculty is an unending struggle, however each course is supervised by a faculty-member-in-charge, and a board of overseers comprised of engineering faculty and industrial representatives advises the CEE administrators.

The U.C. Berkeley CEE program has one advantage - that is, the prestige of the university and its research thrust attract many engineer practitioners to its courses.

So, taking into consideration the special characteristics of UCB CEE programs, let us examine the implications of our findings for improving courses may useful to other programs.

Roles and Responsibilities of the CEE Program Director.

The Program Director is the key to the development of successful CEE courses. Directors should be dynamic, knowledgeable, and effective in working with engineers for they must continually interface with industrial leaders as well as academicians. They must identify industry's needs and locate and convince the best qualified instructors to teach CEE courses.

They must be dilligent talent scouts for they often have to scrounge to get good instructors. They must persuade engineering faculty members that Extension teaching is a legitimate function of the university and overcome

the negative attitudes some academicians hold about teaching CEE courses. Also industrial leaders need to be convinced that university professors can teach practicing engineers effectively. Some CEE experts claim that professors are not the best instructors for practicing engineers because they usually lack industrial experience and an understanding of the realities of engineering jobs (Meadow, 1977). Professors have also been criticized as not adequaltely prepared to teach state-of-the-art CEE courses by those who credit industrial researchers with producing most of the significant applied research. Undergraduate textbooks and courses are often ten years behind the time and journal information lags behind current research by several years.

However, in a prestigious institution like University of California, Berkeley, the greater problem is how to make CEE teaching attractive to professors who have state-of-the-art information that would be useful to practicing engineers. Extension teaching is viewed as a third-rate endeavor for faculty who consider teaching and research their highest priority and rank undergraduate teaching as second.

Locating good instructors from the industrial research community is not easy either. Finding an engineer who is open enough to share information about current research without running the risk of revealing company secrets is difficult. (Even when speakers are open to discussing their research, students remain unconvinced when they say that the problems are still unsolved, preferring to believe that the speaker's company has solved the problem, but does not want their competition to know about it.)

Program directors must keep their fingers on the pulse of industry and know what courses are needed. It would help to be clairvoyant so that one can predict what information and skills engineers will need in the near future. Short of this, directors must maintain personal contacts with industrial leaders and know how to collect needs-assessment data quickly and cheaply. (Rarely do program directors have the time and money even if they had the inclination to perform large-scale formal needs-assessment surveys.) Directors must keep up with the areas in which knowledge is growing rapidly so that they can anticipate technological changes.

Once they have identified potential topics and instructors, the director must help the instructor decide on how to package the information into courses that will be acceptable both the engineering faculty and industry. The packaging should serve a more rational purpose than Extension's need to fill courses. In some cases, we observed courses that covered several specialties, and found that when participants had narrowly limited interests they complained their interest was given short-shrift in the course.

CEE Directors should help instructors plan their courses, give them information about the probable characteristics of their adult students and describe the pitfalls to avoid.

For example, the CEE Director should monitor course titles, course descriptions, the schedule, as well as the course brochure and other publicity.

Course titles should be clear and accurate. Calling a CEE course, "Fundamentals of . . . ." will draw many students who have no background in the specialty. If the instructor aims his presentation at the hypothetical average student (somewhere between the novice and the state-of-the-art researchers), his presentations may be over the heads of most of the class.

A course covering the same content, speakers, and level could be called "An Overview of ...." and not discourage as many students even though some inexperienced people will enroll. Or if the instructor's aim is to present state-of-the-art information, the course could state that "only enough fundamental will be covered to help students understand new developments in the field."

If two topics are to be covered in the course, the title should accurately reflect the emphasis on each. For example, if the title is "Planning and Design', both planners and designers will attend and may expect equal time and or equal emphasis. Dissatisfaction arises when the designers for example, feel the course has not given them the information they expected. One way this problem might be eased is to permit the designers , for example, to attend only those sessions of interest. Another way is to plan the course so that design information is an integral part of most or all of the presentations. If the latter strategy is followed, it should be clearly described in the course announcement.

Course descriptions should be as clear and as specific as possible and accurately reflect course content.

It seems that more care, effort, time and dollars go into designing the artwork, colors, and layout of the brochure that advertises the course than in writing the course description or even in preparing the course materials.

The course description must be carefully worded, and some instructors may need more editorial help for Extension than they presently get. At a minimum, the course description should include the following: 1) the topics to be covered, 2) the rationale (Why should a student take this course?), 3) the expected outcomes or goals (What does the instructor expect to achieve?), 4) a description of the level of experience or background

expected of students, (If the instructor assumes prerequisite knowledge this should be clearly stated), 5) a description of the instructional materials (textbooks, manuals, etc.), and 6) a statement about instructional techniques (lectures, discussion groups, question and answer panels, etc.)

If course materials are not sent to participants in advance of the course, it would be very helpful to list a few basic references in the announcement so that engineers who want to prepare themselves for the course may do so.

It is a good idea to include the class schedule in the brochure and the program director should see that it is not too crowded with topics, that sessions are not too long, that ample time is allowed for discussion, that breaks are long enough (15 minutes is too short), and that lunch periods permit participants time to relax a little, eat, talk and digest their food. (In other words, don't show technical films during lunch hour.)

Students in short-courses often suffer from information-overload and may complain when they feel sessions are too long. Shorter, more specific, well-organized formal presentations with more time allowed for discussion would, in our opinion, maximize the students' ability to absorb, retain, and transfer the course information.

One practical problem in preparing course descriptions and schedules is that the brochures are printed four to six months before the courses are given. I suspect that instructors sometimes forget what they have written between the time the brochure goes to press and the week before the class starts when they pull their final product together. Although speakers and even the schedule may need to be changed, this should not be an excuse for vague, cursory course descriptions. The course goals, topics, should

remain essentially the same regardless of changes in speakers and times.

Course Materials Engineers who take CEE short-courses need and expect to received complete outlines of the presentations. In information-intensive courses it is a practical impossibility for many engineers to take adequate notes. Ph.D's complained more often about the lack of lecture notes in courses where they were not distributed than did engineers with other types of degrees. Copies of viewgraphs and other a/v materials are also expected in the materials given out in the class. (See discussion on page 27.)

Developing good comprehensive courses notes and other materials for students requires a great deal of time and effort to write, edit, and reproduce. This is an area in which Extension could help by providing instructors with more technical writing and editing assistance. Also instructors in CEE courses must update their materials each time the course is offered. Instructors may need additional incentives to do this.

At a minimum, course materials should include detailed notes of the main lectures in hard copy, copies of viewgraphs that are labeled, other articles or research material with their relevance to the course explained clearly, and bibliographic references.

Because engineers often enroll in CEE courses to get the materials, improving the materials would pay-off in increased student satisfaction, increased clientele, and an improved probability that the participants would be able to apply course concepts and technology to their work.

CEE instructors seldom send out course materials to students before the class begins, in fact, the materials are usually pulled together at the last moment. There does seem to be some justification for encouraging instructors to send materials in advance, particularly in highly specialized,

technical, one-day programs. Students were more favorably disposed to the subject in course where this was done and a number of engineers requested this in courses where it was not done.

HELPING INSTRUCTORS DEAL WITH STUDENT DIVERSITY

Another important function of the CEE Director is to help instructors understand the special problems in teaching adults and help them avoid some of the pitfalls that can occur.

The range of preparation of students in a CEE class poses problems for engineering professors who are accustomed to teaching their specialty to relatively homogeneous classes in a tight, sequential curriculum. A CEE class may seem to include the equivalent of a herd of sophomores, a gaggle of junior and senior engineers, a handful of the professor's best graduate students, and a few people who walk off the street. Each student has a unique perception of the course and different practical needs.

In planning state-of-the-art one-day courses, experienced CEE instructors usually build omnibus programs that sacrifice depth for breadth and include something for every level-that is, some fundamentals, a bit of theory, current research findings, practical examples and applications, and speculation on future developments. Speakers are chosen to present each of these Industrial representatives teach along with engineering professors. Inevitably the speaker who presents the theoretical material, regardless of his or her speaking prowess, earns lower student ratings than the lecturer who describes applications. The overly-theoretical college professor is thus as at disadvantage in CEE courses, but so is the speaker from industry who confines his examples to one process or product when the class is comprised of people working in different industries or with different products.

Large state-of-the-art one-day courses attract diverse students, but only about one-fifth are new to the subject. They also provide a variety of speakers and topics to meet participants' varied needs. Serious problems arise only when the schedule goes awry and some topics are not covered as thoroughly as the participants anticipated or when speakers are poorly prepared, inadequate in delivery or present purely theoretical or mathematical talks.

We found that instructors had the greatest difficulty teaching smaller classes (under 50 students) when students varied greatly in background and experience and when about half of the class were novices in the field. The courses that students rated the best and where there was more evidence that participants transferred the information from the class to their work were highly specialized small (enrollments of under 20) with relatively homogenous students. For example, participants in the Value Engineering course teneded to be older, highly experienced engineers working in design and construction. Smilarly the microprocessor course drew people with previous experience with computer programming.

As we have mentioned before, there are things that instructors can do to reduce the diversity of students in their CEE courses - such as making sure that the course title reflects the course content, and clearly describing in the course brochure the level of the presentations and the prerequisite knowledge and experience needed to understand the course in the course brochure.

However, if one cannot restrict enrollment to those who might profit most from the course, it would always help if students answered a few questions about themselves before the course begins. With these answers there would be fewer surprises. Instructors would have some idea of the students' backgrounds and interests. A simple pre-questionnaire like this one could be printed on the brochure and sent in with the registration form:

Pre-Questionnaire

1. Briefly describe your present position.
2. Is your work primarily managerial_____ technical_____other_____
3. What are your reasons for taking this course?
4. Have you taken other courses in (course topic) or related courses? If yes, what where and when?
5. Does your present work involve (course topic?) If so, how?
6. How long have you worked in your present specialty?
7. What is your highest degree? When did you receive it?
8. What do you expect to learn in this course?

Instructors should be encouraged to try different teaching methods to better meet the needs of adult students. CEE courses are rarely sequential- that is, there are usually not separate courses for beginning and advanced students and everyone, regardless of background and experience, enrolls in the same course. Therefore, it is important that these differences be recognized within the class by providing optional sessions, more discussion groups in which experienced practitioners could share their practical knowledge, adding on a hands-on lab for newcomers, or an extra review session on fundamentals. Instructors seem reluctant to try other teaching models other than lecture/ discussion. To deal with the varying adult learning styles and capabilities, an eclectic approach to teaching is needed. That does not mean that lectures should be eliminated - they are essential and a good way to convey information quickly to a large number of people. Engineers, like other professionals, do not want to waste time, and prefer good, well-organized lectures. However, there are practical limits as to how much can be absorbed from a full day or a full week of listening to lectures.

Holding concurrent sessions during a course where students from different specialties could chose to attend one or the other has not been tried in the courses we observed. Everyone sits through all the presentations.

Another method for insuring that students transfer skills and knowledge is to plan brief follow-up sessions - e.g., 4 to 6 weeks after the original course. This would give instructors a change to provide feedback to students - a condition that maximizes transfer. (Guiliani, 1979)

Additional CEE courses are needed - i.e., courses that engineers can take after they are turned on to learning more about a topic by a one-day course. It is vital that general courses be followed by intensive programs that provide hands-on work or more advanced concepts. This is a need that is not being currently addressed by Extension.

Evaluating Courses The CEE Director also has a responsibility for evaluating courses on a more sophisticated basis than whether the course enrollment fills and the dean receives no letters of complaint from students. Without some additional evidence of a courses's value, few risks are taken - that is, if the course filled, it is offered again without change.

Compiling a simple data base (such as that shown in Appendix B) is a first step in gathering information for evaluation. Designing questionnaires for end-of-class administration, and an occasional follow-up of a random sample of students are other ways. People do not like to count and analyzing course questionnaires does take some clerical time. As we have shown, it isn't the absolute number of complaints that instruction is not meeting engineers' needs that makes the difference. But rather, instructors seem unaware of the number of inexperienced students in their classes and novices are the ones most likely to complain that the subject matter and presentation are over their heads.

Changing Industry's Views About CEE Gathering simple data on the value of courses can help fill another need - that is, the CEE Director must assume a missionary role and convince industrial representatives to change their attitudes about CEE. Students who have completed courses need to be offered opportunities to take more responsibility, and challenged to use the information and techniques learned.

Somehow the attitude that taking CEE courses is something one does on one's own if the company pays - like a fringe benefit - needs to be changed. With adequate evidence of the value of CEE course work, a director might be able to convince companies that they too can benefit if they encourage engineers to apply new information.

In summary, the CEE Director serves many roles and devising simple but effective ways of evaluating the programs is one of the most important.

Unanswered Questions In this project we have looked at participants' reactions in 10 CEE short-courses and used these data to develop a simple model for evaluating CEE short-courses. A spin-off of this effort has been a number of suggestions for directors and instructors given in the preceding section.

Time and money limited the amount of follow-up and analysis that we could do. We did find a number of questions that we were unable to answer, and these might aid other investigators in further investigations:

1. Taking a CEE course seems to increase participant's interest in taking additional courses or further study. How long does this enthusiasm last? Do engineers continue to take courses or do they find other ways to fill this need?

2. How often do engineers need updating? In the courses we examined some people come back every year, others every two or three years. Certainly attendance at some of these courses depends on how rapidly the technology

in the field is changing, but, aside from that, are there any yard-sticks for predicting when one should return for a refresher?

3. Do engineers who complete CEE courses transfer jobs more frequently than those who don't take courses? We found that the ability to apply information learned on the job is a function of the job setting and company constraints. If an engineer returns to work desiring to try something new and is thwarted - what happens?

4. It was surprising to us that very brief one-day programs resulted in changes in work and transfer of training with some participants. What are the factors that make this possible? Are they all job-related or are some related to the nature of the individual? Are there ways of determining who will profit from a CEE course? Are there ways of packaging or advertising the courses that would attract engineers who presently do not attend CEE courses?

5. How might courses be designed to maximize the chances of an engineer spreading the information to others in his/her company? Are there ways companies could encourage this?

These are some of the questions that still intrigue us.

To summarize: In this project we developed a simple model for evaluating CEE short-courses, based on the problems, processes, and findings of 10 evaluations of U.C.B. CEE courses. The model developed addresses three major areas of outcomes: educational development, improved morale/sense of efficacy, and improved job performance. Under these three categories are 15 specific outcomes and two types of evidence for classifying results. A gradient of statements reflecting the impact resulting from CEE education was sketched. To place the outcome evidence in appropriate

context, it was suggested that characteristics of the job setting and personal characteristics of the participant be considered.

Routine evaluation of CEE courses can be done inexpensively by improving end of course questionnaires and including some demographic questions (i.e., it is important to know the student's reasons for taking the course, the amount of experience he/she has had in the specialty, and background in the subject, etc.) Compilation of a simple data base from this information will ease planning. In our study we found, for example, that engineers who were inexperienced in the specialty were more likely to complain that instructors put too little emphasis on applications. These engineers although newcomers to the specialty tended to be older engineers who were considering or had just made job changes. Perhaps much of the concern about job obsolescence has been mis-directed by over-emphasizing the engineer who remains in the same specialty throughout his career. It may be more realistic to recognize that many engineers are forced into mid-career changes and given limited time to prepare for new specialties. This group is rarely addressed directly in the planning of CEE courses, and perhaps some of the suggestions we have made for improving CEE courses will aid their plight.

Dissemination of this Report. A copy of this report will be sent to the ERIC Clearinghouse for Continuing Education and copies will be sent to 75 libraries. In addition, copies of the abstract will be sent to 100 industrial training representatives.

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APPENDIX A

INSTRUMENTS USED IN STUDY

STUDENT QUESTIONNAIRE
ITEMS

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its engineering short courses. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

Please fill out the following items carefully. Most questions can be checked, but a few require short answeres.

We appreciate your taking the time to answer these questions. The information you give will be held confidential unless you agree to release it.

I do ( ) do not ( ) wish the information I give to be released to my company.

(Note: We found that the more students answered the questions when the release statement was at the end of the questionnaire.)

Demographic items

What is your job title? Your highest degree?

In what year did you receive it (or year)?

What % of your time is spent in:
( ) managerial duties
( ) technical duties
( ) sales/marketing
( ) other (what?)

(Note: other alternatives used in this item varied with the course including: test/quality assurance, production, design, structural engineering, research, production processes, contracting.)

Do you work primarily in:

( ) R & D
( ) Production
( ) Planning and Decision-making

(note: other alternatives were used depending on the course.)

Demographic items (continued)

How long have you been in_____? (lithography or whatever the course topic is.)

(Revised to: How many years has your work involved earthquake engineering , or whatever the course topic is?)

(For some of the computer courses we asked questions like;)

How much experience have you had in using computer analysis techniques for designing buildings?

( ) Have written applicable computer programs.
( ) Have performed computer analyses.
( ) Have used and interpreted the results of computer analyses.
( ) Have had other experience, Explain
( ) Have had no experience

(for value engineering we asked: Are you employed by the goverment?

How many people do you supervise?

How much opportunity is there for you to disseminate the information you learned in this course to other in your company?

How well prepared were you for this course? or

How many courses in _____ have you taken? or

Have you taken this course (or one like it) before?
If so, where and when?

EVALUATION OF COURSE

What were your goals in taking this course? Rank order
1= most important
4= least important

( ) learning the fundamentals
( ) improving general background
( ) updating knowledge
( ) acquiring a perspective for decision-making
( ) meeting others in the field and finding out what they're doing
( ) other (what?)

How well were your goals achieved?

	not at all	somewhat	satisfactorily	very well
Learning fundamentals	( )	( )	( )	( )
Updating knowledge	( )	( )	( )	( )
Acquiring perspective for decision-making	( )	( )	( )	( )
meeting others	( )	( )	( )	( )
other (what?)_____	( )	( )	( )	( )

(Note: on some course/questionnaires the goal questions were combined.)

What were your goals in taking this course?
How well were they achieved?

	not at all	somewhat	very well
( ) updating technical information	( )	( )	( )
( ) knowledge of fundamentals	( )	( )	( )
( ) perspective for decision-making	( )	( )	( )
( ) meeting others in the field and finding out what they're doing	( )	( )	( )
( ) improving job skills	( )	( )	( )

(Note: on some questionnaires we included "getting an overview of current research," "learning advanced theory," "Solving process problems," etc. at the instructor's suggestion.)

Evaluation of course continued

How did this course compare with other engineering short courses you have taken? (In usefulness, content, interest)

( ) the best I have taken

( ) better than others

( ) about the same as others

( ) less satisfactory than others

( ) have taken no others

Rate the course on the following:

pace	( ) too fast	( ) about right	( ) too slow
length	( ) too long	( ) about right	( ) too short
difficulty	( ) too hard	( ) about right	( ) too easy

How would you rate the instructors' emphasis on the following?

	too much	about right	too little
current research information	( )	( )	( )
fundamentals	( )	( )	( )
application	( )	( )	( )
theory	( )	( )	( )

Was there something you expected to get from this course, but did'nt? if so, what?

Evaluation of Course continued

How effective were the various forms of instruction?

	poor	fair	good	excellent
team workshops	( )	( )	( )	( )
films	( )	( )	( )	( )
lectures	( )	( )	( )	( )

Was there something that you expected to learn in the course, but didn't? If so what?

How might this course be improved?

Outcomes and Applications

Do you plan to do further study on the topics in this course?

( ) yes, as part of my job
( ) yes, on my own time
( ) doubt that I'll do more study
( ) am sure I won't

OR

Have you sought further instruction or done further individual or company research on the topics in this course?

( ) major company research area
( ) have done considerable research on my own time
( ) have taken additional courses
( ) no

Outcomes and Applications continued

How useful have the lecture notes and/or other courses materials been to you

( ) very valuable ( ) quite useful ( ) not useful

Which phases of the workshop will be most useful to you in your work? either immediately or in the long-term?

	Of immediate use	Of future use
Information		
Speculation		
Analysis		
Development		
Presentation		

(Note: Topics varied with the course.)

(On the reverse side of this page, briefly describe the ideas & techniques you found most valuable, and how you plan to use them.)

OR

Did you find anything in the course that you could use immediately? if so, what?	Did you find anything in the course that you can use in the futre? If so, what?
TABS	
ETABS	
DRAINE 2D	
DRAIN-TABS	

(Topics varied with the course)

(On the reverse side, briefly describe the ideas and techniques you found most valuable and how you used them.)

Have you discussed the information gained in this course with your company colleagues ( ) supervisor ( )

Do you think that taking this course has helped you professionally?
( ) yes ( ) no ( ) am not sure

If yes, explain:

How much did your company benefit from sending you to this course?

( ) a great deal ( ) somewhat ( ) not at all

Explain:

Would you recommend this course to a colleague? ( ) yes ( ) no

Company Support of CEE Courses

Who initiated your decision to attend this course?

( ) I did ( ) my superviser ( ) I was selected by my company

How does your company support/recognize attendance at courses like this one?

( ) company strongly encourages attendance
( ) company pays fees and expenses (Full- Partial-)
( ) company grants released time (time off)
( ) course attendance increases possibility of promotion/ raises
( ) no particular encouragement

I would like to participate in a short course on:

Other remarks?

Final Statement

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

( ) perfer telephone interview
( ) want further information
( ) do not wish to participate

( ) I'd like a summary of the final report.

Please return questionnaire to:
Engr. Extension #XT37
U.C.B., 2223 Fulton, Berkeley, CA 94720

PARTICIPANT INTERVIEW DATA SHEET

Code # _____

Course_____ Name_____

Date Interviewed_____ Phone_____

Interviewer_____ Job title_____

How does your job involve the topics covered in this course?

Why did you take the course?

How much did you know about the topics beforehand?

How do you feel about your knowledge now?

Have you had a chance to use information learned in the course?

If so, how?

Have you used the course notes and other materials? How often?

For what purposes?

How many people do you supervise? Has there been a chance for you to spread information from the course?

Have you been able to make any changes as a result of taking the course? Describe.

Have you taken any related courses since taking this one?
If so, what? Had you had any before this one?

Where else could you get instruction on these topics?

Was the course oriented toward practicing engineers?

What do you think about the way that the instructors presented the class? Could you comment on specific instructors?

Are there better ways to run a class like this?

Are there any other topics you'd like Extension to present?

Is there someone in your company that handles outside education? Anyone in your department that might have suggestions for needed courses or give us an idea of how much your company has gained from having you take this course?

If so, names_____title(s)_____

phone #'s_____

Is there anything else you'd like to add?

FACULTY INTERVIEW PROTOCOL

Instructor's name_____Course_____

1. Would you explain the specialty (content) the course addresses?

2. What other sources of training are there in this specialty? (i.e., are courses included in undergraduate/graduate engineering schools? company training programs? others? If so, how long do these courses last? How do they differ from this CEE course?)

3. What do you see as the major goals of this course?

4. What kinds of students do you expect to attend (Background preparation, reasons for enrolling? Engineers? Others?)

5. What do you estimate the educational background of the course participants to be? (% BS, %MS, % PhD? Other?)

6. Have you taught this information as a CEE course before? grad/undergrad course? Other?

7. Do you aim this course toward any particular educational or experience level?

8. How was the course selected?

9. How did you decide on the teaching methods used in the course?

10. How did you select speakers?

11. What kinds of problems do you expect students to have in learning the course material?

12. Will course notes or other materials be given to the participants? If so, please describe them

13. What kinds of effects do you expect the course to have on those who taken it? (Examples of transfer.)

(Other questions were tailored to each course. For example, we asked the Value Engineering instructor about the importance of certification; how companies recognized CEE participation; whether government employees would enroll, etc.)

NSF Proj. XT-37
M. Maxwell

Follow-up Interview Form (for superviser, colleague,or subordinate.

Name_____Phone_____Company_____Date_____

Interviewed by _____ Code #_____

1. Introduce self and explain purpose of NSF Project.

2. Explain that _____ has consented to let us
(name of student)
interview you regarding the impact of CEE courses on the company. We're interested in how the company gains from sending representatives to CEE courses and what impact these courses have on employee's job.

3. In general, how do you feel the company benefits from sending representatives to CEE courses?

4. What effects have you observed from ____ attending the course?

Examples: code: changes in work productivity
procedures
persepctive
techniques
work with clients
work with colleagues
other:
problem-solving

5. Has _____ implemented anything new?

Examples:
programs
research
decision-making
procedures
other?

6. Has _____ disseminated information learned in course to others?

Examples: who? superviser, coll., subord.
how? passed around materials/memos
presented info. in meetings
discussed informally
informal discussions/brain-stormed

7. Do you feel course contributed to _____'s professional development?
If so, how?
increased skills in___
understanding of___
confidence in ____
leadership in ___
job skills in ___

Interview Form (superviser, etc.)

8. Other specific benefits to company?

9. Any negative spin-offs of taking CEE courses?

10. Suggestions for needed courses/ ways courses could be improved?

A-13

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

UNIVERSITY EXTENSION

2223 FULTON STREET
BERKELEY, CALIFORNIA 94720

June 11, 1979

TO: Students in the 1978 Airport Systems Planning and Design Course

Engineering Extension, under a grant from the National Science Foundation, is conducting an evaluation of its short-courses for engineers. Your responses to the questions on the attached questionnaire will help us find ways to improve our courses and to develop a model for evaluating future courses. We are particularly interested in finding out whether and how you have applied ideas and techniques learned in the course to your work.

Your responses to this survey will be kept confidential. However, we have included your name on the questionnaire so that we will not have to bother you with reminder letters.

You may request a summary of the evaluation results by checking the box at the end of the questionnaire.

Please take a few minutes to answer the questions and return the form in the enclosed, pre-addressed envelope.

If you have any questions about the survey, please feel free to call me at (415) 223-5947.

Thank you for your help.

Sincerely yours,

MARTHA MAXWELL, Ph.D.
N.S.F. Project Director

P.S. We are also asking for volunteers for case-studies of the impact of Extension courses. If you are willing to be interviewed by the project team, and permit the team to interview your supervisor and colleagues, please indicate this on the questionnaire.

APPENDIX B

EXAMPLE OF A DATA BASE

DATA BASE (406 Respondents)

I. Student Characteristics

1. Educational Background

High School -	1%
Assoc. Deg.	
Some college	6
B S	45
M S	30
PH D	18

2. Year received highest degree.

78-9	9%
76-7	13
70-5	31
65-9	19
60-4	11
59 or earlier	18

3. Percent of time spent administration:

0%	25%
10-29	31
30-39	9
40-49	6
50-69	16
70-89	8
90-100	5

4. Percent of Time in Technical duties:

0%	3%
10-29	13
30-39	4
40-49	4
50-69	19
70-89	17
90-100	41

Note: Not all participants answered all questions and the data presented are not weighted by class size. Therefore, this table serves only as a general model of kinds of information one might compile in a data base.

5. Number of people supervised:

None	13%
1 - 2	16
3 - 4	29
5 - 10	40
10 or more	9

6. Number of years in field:

Less than 1 year	23%
1 - 2	22
3 - 5	15
5 - 10	12
10 or more	28

7. Who initiated your taking the course?

Sent by company	10%
Supervisor Recommended	26
Self-initiated	63

8. Company support of CEE course attendance:

Company pays fees & expenses	95%
Company gives time off	93
Company strongly encourages attendance:	82

9. Previous courses on this topic?

Yes - 26 %
No - 74 %

10. Previous CEE short courses?

Yes - 66%
No - 33%

II STUDENT EVALUATIONS

1. Degree to which goals in taking course were satisfied:

Goal - update knowledge (% checking this as goal = 75%)

Satisfaction:

Not at all	5%
Somewhat	40%
Satisfactory	15%
Very well	40%

Goal - learn fundamentals (% checking this as goal = 67%)

Not at all	6%
Somewhat	43%
Satisfactory	17%
Very well	34%

Goal - Improve general background

Not at all	6%
Somewhat	29%
Satisfactory	31%
Very well	35%

Goal - Solve Problems

Not at all	19%
Somewhat	64%
Very well	17%

Goal - Acquire perspective for decision-making (65%)

Not at all	13%
Somewhat	47%
Satisfactory	12%
Very well	28%

Goal - Meeting others in the field (55%)

Not at all	18%
Somewhat	51%
Satisfactory	13%
Very well	19%

Goal - Improve job capabilities (10%)

Not at all	15%
Somewhat	47%
Satisfactory	7%
Very well	31%

Goal - New Field

Not at all	13%
Somewhat	18%
Satisfactory	19%
Very well	50%

2. Comparision with other CEE courses taken:

Best	7%
Better than others	30%
About the same	25%
worse	6%
Have taken no others	33%

3. Usefulness of course material:

Doubt that I'll use them 10%
May use them 37%
Expect to use them regularly 53%
(Very valuable)

4. Outcomes:

Interest in taking other courses: (write-in)
Yes 45%

Plan to take further courses
Yes 72%

Plan to do further research on course topics on own?
Yes 77%

Plan to do further research on job?
Yes 75%

5. Application of Information learned in courses:

No. Topics/ideas can use immediately

0-39%
1-25%
2-15%
3-4-14%
5+-5%

No. Topics expect to use in future

0-45%
1-23%
2-17%
3-4-10%
5+ -5%

No. examples given:

None-69%
one-19%
two-8%
three-2%
four or or-more 2%

6. Was there something you expected to get from the course, but did'nt?

Yes - 58%
No - 42%

7. Evaluation of aspect of course:

	Too Fast	About Right	Too slow
Pace	13%	81%	7%
	Too Long	About Right	Too slow
Length	13%	55%	32%
	Too Hard	About Right	Too Easy
Level	14%	66%	20%

Instructors' Emphasis on:

	Too Much	About Right	Too little
Research	5	74	21
Applications	2	59	40
Theory	13	75	12
Fundamentals	8	81	12

8. Written suggestions for improving the course: (Based on 217 comments)

Improve materials	27%
Organization	22%
Instructors	15%
Content/Topics	13%
Focus more on Engrs. needs	11%
Facilities	8%
Other	4%

III. Other Items:

1. How well prepared for this course were you?

Unprepared	13%
Somewhat	26%
General Background	24%
Well Prepared	35%
Very Well Prepared	3%

2. Willing to be interviewed ? 22%

   Were interviewed 15%

(Note: 68% of those willing to be interviewed, were interviewed)

APPENDIX C

EVALUATION REPORTS ON INDIVIDUAL CEE COURSES

Course	Page Number
Fundamentals of High Resolution Lithography	C-1
Composite Materials Computation Workshop	C-2
Value Engineered Design and Construction	C-3
Electron-Beam Lithography	C-4
Airport Systems and Design	C-5
Exponential Smoothing and Adaptive Forecasting	C-6
Earthquake Analysis of Multi Story Frame & Shearwall Buildings	C-7
Engineering Design in Timber	C-8
Computer Aids for IC Technolgy and Device Design	C-9
Interfacing to a Microcomputer	C-10

EVALUATION OF "FUNDAMENTALS OF HIGH RESOLUTION OF LITHOGRAPHY",
A University of California Engineering Extension Course Offered
February 23, 1979.

Evaluators:
Martha Maxwell
Caroline Showers

Faculty Coordinator for the Course:
Andrew Neurether, Assoc. Prof.
Electrical Engineering & Computer
Science, Dept. U.C. Berkeley

About Lithography

Lithography is one of the seven technologies in the electronics field that contribute to the development and manufacture of calculators, computers, and other electronic devices. In this field, the word "lithography" means the technique of writing large amounts of information in the form of electrical circuits on a very small area, the proverbial pinhead. The limits of high-resolution lithography, rather than those of the other six technologies, constitute the limits on production of a new electronic device. Now 15 years old, lithography has for 5 years set the limits to all the other technologies in this field.

Company training in lithography enables a new employee to make a contribution to the field in about 6 months. Experienced workers tend to stay within device fabrication (the conglomeration of the seven technologies) throughout their career, but have considerable mobility across technologies. Those who move into managerial positions usually have charge of at least two of the seven technologies. The only formal training in lithography that a university student receives is that gained in research for a master's or doctoral degree on a relevant topic.

Description of the Course

Fundamentals of High-Resolution Lithography was a one-day course intended for engineers who are present or potential users of new lithography systems. The course brochure described the four lectures as providing 1) a practical conceptual foundation for the field, 2) a detailed discussion of new developments, and 3) a survey of alternatives for VSLI lithography with reduced linewidth capability. The topics included 1) Deep-UV Lithography, 2) a User-Orientated Simulator for Projection Printing (SAMPLE); 3) E-Beam and X-Ray Lithography, and 4) Composite Processing for High-Resolution Lithography. These topics were presented by the speakers in lectures (ranging from 75-105 minutes in length) with a few minutes for questions after each talk and a 15-minute general question discussion period at the end of the day. Participants were given 15-minute coffee breaks in the morning and afternoon and a one-hour lunch. A social hour was scheduled at the end of the day, but there were problems in getting it set up so most of the participants left after the discussion session.

Two of the speakers were from major industrial research centers and two were university professors.

METHODOLOGY

This evaluation is based on the results of questionnaires administered to 90 students at the end of the course, follow-up interviews with 20 students, and interviews with the faculty-member-in-charge before and after the course.

Student Questionnaire

Evaluation questionnaires were distributed to students immediately before the panel discussion at the end of the day, and were collected at the conclusion of the program. One hundred and thirty-two people attended the course and 90 questionnaires were returned. The questionnaire included 21 items, only two of which were open-ended (participants were asked to describe the topics they found most valuable, how they would use them, and to make one suggestion for improving the course.) All other items involved checking the appropriate alternatives or giving one-word answers stating, for example, job title or degree level.

Items on the questionnaire can be roughly classified into four groups. Demographic items (1-6) investigate amount of education, nature of professional duties, and experience in lithography. Another group of questions (7,8,9,11,14,16,21) focuses on the effectiveness of the course: 1) How well participants' goals were achieved; 2) How information gained will be applied in the job setting; and 3) How well the course compares with other short courses for professionals. A third area of investigation (Items 12,13,14, 16) is company attitude toward state-of-the-art courses. Finally, participants were requested to indicate their interest in taking future courses and participating in follow-up interviews (Items 17,19). (See Appendix A for the questions and summaries of the responses.)

1. Demographic Characteristics of the Students

About half of the respondents described themselves as a manager, supervisor, or director. Yet, on the average, they spent 71% of their time in technical duties. About an equal number of students had Ph.D.'s, Master's, and Bachelor's degrees with 62% holding graduate degrees. Sixty-nine percent of the respondents had received degrees in the last ten years. Most worked in research and development; about 20% were in production; and a few worked in planning or marketing. Almost half the class had less than one year's experience in lithography (or were not employed in the field.)

Overall, the group appears to consist of well-educated, successful workers involved in technical R&D activities, but without a great deal of experience in lithography.

2. Goals and Applications

Seventy-seven percent of the students reported that they took the course to update their technical knowledge and most were satisfied that the course met this goal. (39% reported it did so "very well".) Fifty-seven percent checked "knowledge of fundamentals" as their goal and were somewhat less satisfied with the course results (only 20% stated that it satisfied this goal "very

well".) It was surprising to find that almost half of the respondents with more than 5 years in the field cited knowledge of fundamentals as their goal (see Ap.A, p.ii) Forty-eight percent of the group took the course to gain a perspective for decision-making and most were satisfied that the course helped in this regard. Meeting others in the field and finding out what they're doing was a goal of 30% of the group, and, despite the short length of the course, most of these reported they attained this goal "somewhat".

When asked to predict immediate and long-term applications of the course topics, about one-third of the class stated that they found information that they could use immediately in Deep- U-V, SAMPLE, or compatible Processes. Over half of the group stated that the material on E-Beam and X-Ray would affect their work in the future. (Note: these processes have not yet been fully developed for most industrial applications.) A list of the topics students found useful and ways they plan to apply them is included in Appendix B, p. 6.

Most respondents expected to report information about the course to their supervisors and/or colleagues. Since only 30% mentioned that their supervisor suggested they attend the course, it may be that these will be informal reports. Thirty percent of the students said that the course topic reflected a major research area in their companies. This figure may reflect the importance of the topics and the effectiveness of the course in meeting engineers' needs. Also, 30% said they planned to take further courses in the field and 39% expected to do research individually on topics of concern to them.

These results suggest that individuals' goals were achieved reasonably well and that most students expect to make use of the material presented.

3. Company Involvement

One-third of the respondents mentioned that their companies or supervisors initiated their decisions to attend the course. A similar number mentioned that their companies strongly encourage attending such courses, or that attendance might increase their possibilities for promotion or a raise. Since all of the students' fees for the course were paid by their companies, industry is obviously amenable to engineers' participation in this type of short course. The fact that 70% of the participants requested their companies' backing in taking the course does suggest, however, that the taking of such courses is regarded as a matter of individual initiative rather than a deliberately encouraged company policy.

As mentioned above, participants expected to pass on material presented in the course to their colleagues and supervisors. Some stated that they would encourage their companies to do further research on these topics. Thus, the topics appear to be important and relevant to company interests.

In general, students in this course seemed to be a highly motivated, self-selected group of professionals.

Comments: The sample of students replying to this questionnaire may reflect an age bias. Of the 90 students returning the questionnaire, 39 said that they had less than 2 years' experience in lithography.

Perhaps younger and newer employees are more willing to take the time to complete a detailed questionnaire than are older managers. It may be that recent employees are more apt to attend courses, or that they interpreted the title, "Fundamentals of High-Resolution Lithography" to indicate that the course covered more fundamental matters than it actually did.

Another sampling bias may be that the people who answer questionnaires may be more favorably disposed toward the course than those who do not.

4. Comparative Evaluation of the Course

Eighty percent of the respondents found the pace of the course about right. With one exception, those who found it too fast had less than 2 years' experience in the field. Most of those who found it too slow had more than 5 years' experience. The course was rated positively in comparison with other professional and commercial short courses attended by participants. A majority of those replying described this course as superior to others. However, this question was answered by only 35 people while the number of responses for all other questions ranged from 67 to 89. Since only 12% of the group had taken this course before, it may be that the majority of students had taken no other courses in lithography on which they could base a comparison.

5. Student Suggestions for Improving Course

Students were asked to give one suggestion for improving the course and about half of the respondents complied. Most frequently mentioned areas were improve course materials (17), emphasize more basics (11), and provide more practical information (6). (See Appendix A, page [illegible] for a list of these suggestions).

Summary

This course attracted a fairly diverse group of engineers in regards to background and experience in lithography. About half the group had little or no experience in the field while others had spent many years in lithography (long enough to be considered pioneers.) More than half of the class had earned graduate degrees and most held responsible positions in R&D. The average student was fairly well satisfied with the course and found one or two ideas that they could apply to their work immediately.

Interview with Faculty Coordinator

The faculty coordinator was interviewed before he was given the results of the course questionnaire. He was asked to predict how the group

SUMMARY OF STUDENT EVALUATIONS OF FUNDAMENTALS OF HIGH-RESOLUTION LITHOGRAPHY
(February 23, 1979)*

1. What is your job title?

19 Technical staff or technician
3 Research staff

Engineers:
- 3 Unspecified
- 1 Field E.
- 8 Process
- 4 Development
- 2 Masking
- 1 Project E.
- 1 Product E.
- 1 Photoresist
- 2 Associate E.
- 1 Software Analyst
- 1 Electrical E.

Other:
- 1 Specialist
- 1 Vacuum Tech.
- 1 LSI circuit design
- 1 Layout designer

1 Physicist
1 Chemist

Managers:
- 3 Unspecified
- 1 QA engineering
- 1 Tech. development
- 1 Tech. liaison
- 1 Digital systems
- 1 Applied Engineering
- 2 Mask making
- 1 QC
- 1 EPROM development
- 1 Design and process development
- 2 Research director
- 1 EBS engineering
- 1 IC process engineering
- 1 Operations head
- 1 Microlithography and process labs
- 1 Microprocess photomasking
- 1 Engineering manager
- 1 MOS design
- 1 CAD manager
- 1 Technical director

General Manager, CA office

Sales engineer
Salesman
Vice-President, Marketing director

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* Percentages represent the fraction of participants responding to each question who gave a certain response. For example, 33% Ph.D. means that 33% of the participants who responded to Item 2 gave Ph.D. as their highest degree.

2. Highest academic degree?

33% Ph.D.
29% M.S./ M.A.
37% B.S./B.A./A.A.

3. Year received? (69% of respondents had received degrees in the last 10 years.)

Frequency Distribution--72 respondents

1978	77-75	74-72	71-69	68-66	65-63	62-60	59-57	41
8	14	16	11	10	4	5	3	1

4. What percentage of your time is spent in:
managerial duties?
technical duties?

37 individuals (42% of respondents) were full-time technicians (that is spent 90% or more of their time in technical duties.)
2 individuals (2% of respondents) were full-time managers (spent 10% or less of their time in technical duties.)

Respondents averaged 71% of their time in technical duties. Three people were in marketing.

5. Do you work primarily in:

f	%	
72	80%	R&D
18	21%	Production
6	9%	Capital Equipment planning or marketing

6. How long have you been in lithography?

27%	1 year or less
23%	2-5 years
32%	more than 5 years
18%	not in lithography

Frequency distribution--79 respondents

0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	28
14	25	7	10	6	9	2	2	3	1

7. What were your goals in taking this course?

		Number responded	How well were they achieved? not at all	somewhat	* very wel
57%	knowledge of fundamentals	44 %	5%	68%	7% 20%
77%	updating technical information	64	-	56	5% 39
48%	perspective for decision-making	32	-	63	6% 31
30%	meet others in the field and find out what they're doing	22	-	77	23

*Figures in this column represent responses checked between somewhat & very well.

Breakdown of Goals By Number of Years in Lithography

	5 Years or Less	More than 5 Years
Knowledge of fundamentals	60%	48%
Updating technical information	66%	88%
Perspectives for decision-making	43%	56%
Meet others in the field	25%	40%

8. How did you hear about this course?

(Frequency distribution--85 respondents)

Brochure	News Release	Prof. Society Newsletter	Company Newsletter	Colleague	Other
68	3	4	1	17	2

9. How well did the pace of the course suit you?

80% About right
13% Fast or too fast
7% Too slow

	Did you find anything in the course that you can use immediately? If so, in what areas?	Did you find anything in the course that will affect your work in the long term If so, what?
Deep U-V	32%	38%
Sample	38%	36%
E-Beam and X-Ray	15%	56%
Compatible Process	35%	36%

74% of the respondents to this question mentioned at least one topic for immediate use; 79% mentioned at least one topic for long term use. (See appendix for list)

10. Have you taken this course before? yes 12% no 88%

11. How does this course compare with other engineering short-courses you have taken? (in usefulness, content, interest)

This question got a poor response (40% of all persons returning questionnaires). 57% of the respondents rated this course as superior to others they had taken; 43% found it about the same; no ne gative responses were given.

12. Who initiated your decision to attend this course?

you 73% supervisor's suggestion 30% selected by company 3%
(Note: some students checked more than one alternative)

13. How is your attendance supported/recognized by your company?

100%	payment of fees and expenses	24%	company strongly encourages attendance
49%	released time	6%	attending courses increases possibility of promotions/raises

14. Will you report the information gained in this course to your company collegues? 83% your supervisor? 75%

15. Do you intend to seek further instruction or do individual or company research on the topics in this course?

30% major company research area
30% plan to take future courses
39% will do research on my own
\- am not sure

16. Are you interested in taking courses in: process-modeling 41, e-beam 33, other ___, STudents mentioned the following courses:

Basic processing concepts
Overview of process
Semi-conductor
Critical measurements
X-Ray, resist
LSI design
Photolithography
Sputtering
Dry processing
Deep U-V

(84% of students returning questionnaires answered this question)

17. What one suggestion do you have for improving this course?
(Responses are coded by area. Numbers in parentheses are the number of persons giving each suggestion. 43 students --48% of the respondents--answered this question.)

Facilities (6)
1 Non-smoking area
1 Uncomfortable seating
1 More food
2 Bad lunch
1 Crowding

Lecture notes (17)
Most commented that notes were out of order.
1 More detailed diagrams
1 Complete bibliography
3 Suggested a pre-course handout
1 Desired copies of all diagrams presented

Suggestions for Improving Course (cont'd)

Logistics (2)
- 1 Better timing
- 1 Have monitor speaker in A.M.

Length (1)
- 1 Two-day course would be more practical

More basics (11)
- Assume less advanced knowledge
- Present more basics/ a basic understanding/ basic principles
- More detail, basic theory
- Include basic optical theory of projection
- Offer an intermediate level course (this one was too advanced)

More practical information (6)
- 2 Less theory
- 3 More practical material
- 1 More production information

Other (5)
- 1 Add an introduction to each talk (an overview) and have a slower pace
- 2 Cover less material
- 1 Better organization of material
- 1 Improve presenters' styles

18. The NSF Evaluation Project Team is planning to conduct follow-up interviews with engineers who have taken short-courses. If you are willing to participate in a brief interview to be scheduled at your convenience, please fill in your name and phone number below:

N = 10 prefer personal interview at my company
N = 25 prefer telephone interview
__ do not wish to participate

I do 58% do not 42% wish the information I give to be released to my company.

Descriptions of most valuable topics and how they will be used. (26% of the group answered this question)

Code Numbers:

3	Elegant method for monitoring completion of resist development by use of double exporsures. Also, interesting future possibilities with Sample--not ready for it at this time.
4	I found the talk on E-Beam & X-Ray quite interesting. I will study the handout information in more detail and use this information in evaluating incoming E-Beam-generated masks.
5	Deep U-V: Photoresist development, endpoint control
7	Sample--immediate use of program Deep UV and E-Beam & X-Ray--project planning
10	Sample most likely will be utilized for device design and masking criteria.
17	Sample--to model projection printer images E-Beam & X-Ray--making decision for optimum buy date Compatible process--clues of problems
26	Deep UV-- introduction to the topic, renewed interest applicable to future work Sample-- appreciate awareness of the information, but the topic is too large for such short presentation E-Beam & X-Rwy-- not immediately applicable to my work. Useful information for next generation of devices. Compatible process--most interesting of the presentations. I would have enjoyed more in-depth presentation.
30	Deep UV & E-Beam-- VLSI size decrease Sample--Design for fine lines for VLSI Compatible process--current process design and development
31	Radiation damage, lift-off techniques, computer program
32	E-Beam & X-Ray-- better understanding of mask generation Compatible process--set up and evaluation of plasma etch processes
35	Sample--development determination technique, program for process model Compatible process--pattern transfer technique study
41	E-Beam & X-Ray--alignment strategy, architecture
44	Might use deep UV techniques in processing
47	The information presented will be used as reference material for future R&D work in the area of microwave semiconductor devices.

Most valuable Topics in Course (cont'd)

50	E-Beam & X-Ray--possible approaches to improving some of our lithographic techniques
52	E-Beam & X-Ray--positive resist
57	Sample--optimization of projection printing E-Beam & X-Ray-- some considerations in E-Beam, selection of equipment Compatible process--selection of etching processes
58	I found the talk on compatible processes to be very useful. Will use some of the techniques in making out microwave IC's.
61	Compatible process--effects on plasma processing
66	Deep UV-- presented best data and some usable ideas E-Beam and Compatible process talks rehashed data in literature and were pretty much a waste of time.
81	Discussion of practical problems and relationship to theory in optical imagery, photresist and etch (plasma) processing.
83	References for continued reading E-Beam & X-Ray--possible uses in mask making Compatible process--reactive sputtering looks interesting
90	Deep UV and E-Beam--applications to proximity alignment

EVALUATION REPORT ON THE COMPOSITE MATERIALS COMPUTATION WORKSHOP: A PRACTICAL GUIDE TO DESIGN AND TESTING OFFERED BY UNIVERSITY EXTENSION, UNIVERSITY OF CALIFORNIA, BERKELEY, March 26-30, 1979. (Course Coordinator: Dr. Stephen W. Tsai, U.S. Airforce Materials Lab., Wright-Patterson Air Force Base, Ohio.)

Evaluators: Martha Maxwell, Ph.D.
N.S.F. Project Director

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Research Assistant

The Composite Materials Computation Workshop is intended to provide users and producers of composites with the most current guide to solving problems in design and testing. The workshop uses lectures and drills to relate advanced methods to everyday problem solving. Participants are expected to be totally immersed in this five-day workshop and attend informal 2-hour evening sessions as well as the daily presentations. Participants are urged to bring their own programmable pocket calculators and be familiar with their own operation. Advanced methods in design and testing are given on charts or formulae so they can be readily programmed on calculators and pre-programmed master cards of equations are available for reproduction. The workshop topics include stress-strain relations for unidirectional composites, calculating stresses in laminated composites, changes due to fluid absorption, mathematical modeling of curing and swelling, fatigue, fundamentals of testing and evaluation, and latest methods in micromechanics. The course coordinator is assisted by three speakers and several lab. assistants.

This evaluation is based on the responses of 35 participants who returned follow-up questionnaires sent two months after the course ended and on phone interviews with four participants. Since only 54% of the 65 people who enrolled in the workshop returned questionnaires, the responses analyzed may not be representative of the total class and the results should be interpreted with caution.

Student Characteristics. The people who enrolled in this course were diverse in background. Practical experience with composites, and in the type of composite material their work involves. Nine held bachelor's degrees, 16 held master's degrees, 3 were Ph.D.'s and one had two years of college. Seventy-nine percent had worked in composite materials less than five years, and 41% were new to the field with less than one year's experience. Most worked in research and development and spent most of their time in technical duties. Their work involves a wide range of products from tires to teeth to reentry vehicles. In 60% of the cases, the participant enrolled in the course on his own volition; 40% took the course at their supervisor's suggestion or were selected by their company.

This project was funded by the National Science Foundation under Grant # SED-78-22138. The opinions, finding, conclusions, and recommendations expressed are those of the authors, and do not necessarily reflect those of the National Science Foundation.

Evaluation Report on Composite Materials Computation Workshop

Student Evaluations of the Course. On the average, students rated this course as better than others they had taken. 14% of the group rated it as the best they had taken. No one rated it less satisfactory than other courses. 26% had taken no other course in this field.

Most participants took the course to improve their knowledge of fundamentals and job skills, and to update their knowledge. A smaller percentage checked "meeting others" and gaining "perspectives for decision-making" as goals. Those whose goals were gaining a perspective for decision-making, updating information, and meeting others were quite satisfied with the course, but those who expected to learn fundamentals and to improve their job skills felt the course did not succeed as well. Thirty-four percent of the students said the course did not help them learn fundamentals at all.

The majority held that there was too little emphasis on applications (57%), a higher percentage than is typical in the other engineering extension courses we have evaluated.

Most students rated the instructors' emphasis on fundamentals and on current research as "about right." However, between 14 and 20% of the group stated that there was too little emphasis on these areas.

The average respondent rated the pace, length, and difficulty of the course as about right, however, 11% felt the course was too short. Since the course lasted 5 days, including informal evening workshops, this suggests that students, once introduced to a subject through a brief extension course, may become interested in a more formal, semester-length course or it may show that some students were less prepared for the course and need more individualized assistance than others.

The teaching methods used by the instructors were judged as "good" by the average student with 31% rating them as "excellent."

Half of the respondents indicate that they had used some of the techniques or ideas from the course in their work within two months after completing the course. Eighty-two percent feel that what they gained from the course will be useful to them in the future. The ideas/techniques that they have been able to use and those that they consider most valuable range widely across the workshop topics...some gained very specific information, others felt they developed a broader perspective. Those topics they considered least useful dealt mostly with the more theoretical presentations.

Eighty-nine percent of the respondents made suggestions for improving the course. These were about evenly divided between suggestions for making the course more applied (i.e., more time on testing methods, make sure all programs are covered and that application problems are given, etc.), materials (provide texts on micromechanics, better handout materials, handouts on all viewgraphs, etc.), and organization and methods (too many subjects touched on in too short a time; stick to a generally accepted notation and standardize among instructors, breakdown the course into beginning and advanced sections, etc.).

Evaluation Report on Composite Materials Computation Workshop

Summary and Recommendations. In general, students appeared to be well satisfied with this workshop and most found something of value to them. However, there were some inconsistencies in the participants' reactions. A higher than average percentage felt that there was not enough emphasis on applications--a curious result, especially since the brochure describes the workshop as being "explicitly application oriented" and states that all participants will be able to solve numerous problems immediately after the presentation of the topics. Furthermore students were offered informal evening workshop sessions where they could receive individual help in applying the lecture materials by working problems. Perhaps the brochure led the students to expect too much from the course.

Three other factors may have contributed to the problem...the large size of the class, the fact that students work with such a wide array of composite materials, and the fact that a high percentage were newcomers to the field. Students complained that some of the speakers used only examples from the aerospace industry to which they could not relate. In evaluating other CEE courses we have found that when there is a high percentage of inexperienced participants, there are more complaints about instructors' emphasis on applications, particularly when academic speakers are on the program. It seems that the students who is inexperienced in the specialized field has trouble in transferring general information to his work and needs very clear illustrations that relate directly to his specific job. In this course, participants regarded Tsai's presentations as clear, fundamental, and applicable, but many found some of the other speakers too theoretical, not explicit enough, and not prepared enough for their needs (i.e., they complained about handouts, lack of copies of viewgraphs, etc.) These speakers may have assumed that most of the students were more sophisticated and knowledgeable in the field than they were.

Planning a workshop for students with such a wide range of backgrounds and interests is difficult indeed. Some suggestions the course coordinator might consider in planning future courses are:

1. Encourage speakers to prepare more complete handouts including copies of the viewgraphs presented, and alert them that some of the participants have very little background in their topics.

2. Consider scheduling some concurrent sessions where participants could choose between two sessions--i.e., one more basic, perhaps a review of a previous presentation or discussion of fundamentals, and one involving state-of-the art research.

3. Encourage participants to meet other participants who are working with their particular composite materials, if possible, so that they can share ideas and work out applications of the ideas and techniques presented in the talks to their special needs. Students' needs and interests could be identified at the start of the workshop or in advance if appropriate questions were added to the enrollment form. Also encourage the lab. assistants to identify students with similar interests. Participants can learn much from each other.

4. Reexamine the course description to determine whether it accurately describes what students will get in the course and be able to do with the information they learn. Perhaps it is a bit unrealistic to expect that 65 different students from almost as many different industries, half of whom have minimal experience with composites (and their present jobs), will be able to solve problems immediately and get individualized help on their problems. Since the course is a popular one, perhaps specifying some additional pre-requisites would help.

would answer some of the questions and to explain some of the findings. A summary of this interview is given below.

Q. Why was the course called Fundamentals of High-Resolution Lithography?

A. It seems that students responded to "fundamentals" in the course title and on the questionnaire as referring to fundamentals of theory rather than as an introduction to lithography. On the job, a worker will gain experience in the practical, applied aspects of lithography, but may never be exposed to the physics theory that underlies the various processes (e.g., electron and photon interaction).

Q. Would you comment on why you feel students saw E-beam and X-ray as topics that have potential long-term as opposed to immediate usefulness?

A. Currently E-beam is used for mask-making on the "original" surface but there is a possibility that E-beam may be used in the production process (i.e., making large numbers of copies) in the future. X-ray may be ready for use in the production process in about two years.

Q. To whom was the course aimed?

A. I aimed the course toward a class that I expected to be about 40% new to the field. These people would be interested in a list of references and an introductory talk on the topics. I expected another 40% to be engineers practicing at the state of the art level. These would be looking for a perspective on possible problem areas and for new information. Twenty-percent of the group would have contributed to the state-of-the-art knowledge...that is, these are my research colleagues who may even have written the references cited in the lectures.

Q. Do you think that the student's formal education (i.e., number of degrees) contributed to their interest in and understanding of the course?

A. No -- degrees do not matter much, since there are no academic courses in this field that engineers routinely study.

Q. What were your goals for the course?

A. 1) Knowledge of fundamentals by which I mean background in physics including the nature of electron and photon interactions. About 35% of the class time was spent on fundamentals.

2) State-of-the-art knowledge -- that is, current information on Deep UV and E-beam. About 35% of class time was spent on this.

3) Perspectives -- how to choose among alternative technologies. About 20% of class time was spent on this objective.

Q. How do you think that engineers taking the course might apply the information immediately and in the long-run?

	Immediate Use	Future Use
A. Deep U-V	tricks	buying new equipment
SAMPLE	tool	
E-Beam & X-ray	understanding of fundamental theory, masking	insight; possibilities for production
Compatible Process	silicon gate trick	

Q. What were your expectations when you prepared materials for the course?

A. The handouts were designed to provide the student with bibliographical references, and with copies of the viewgraphs used in the presentations. They were not intended to take the place of each participant's notes or to provide a substitute for presence at the presentation.

Q. Do you expect the students to do further research or take other courses?

A. I expect that most students will do some kind of individual research. Most likely they would use the list of references, look up a publication, and call the individual. Then they might propose that their company do research. This might consist of a 6-month experiment replicating the study they read in the reference, a project that could take 10-100% of one engineer's time. I don't expect that many of the students will take further courses in this field since the only other relevant one is a similar course given by Stanford's Extension Program.

Q. How would you rate this course in terms of basic to advanced; practical to theoretical?

A. I'd rate the course midway on a scale from purely basic material to purely advanced material. I assume that the students had some practical experience and were aware of the practical problems of lithography (as opposed to the theoretical ones.)

I'd also rate the course midway between the purely practical and purely theoretical although I expect that industry might see it as emphasizing theory. While 50% of the course material dealt with theory leading to or deduced from experimental research, this research is extremely practical in nature, based on previous empirical observations. This is a field in which theory contributes little to practice, and thus 5 to 10 times more research in lithography is carried on in industry than is done in the University. Research is thus molded by economic constraints, and theoretical research is not encouraged.

Q. How did you go about planning the course?

A. First, I started with my own ideas, shared them with my university colleagues, and then tried them out on people in industry for whom I act as a consultant. Finally I considered which speakers might be available. Thus, my impressions from professionals in industry about their needs contributed to my planning the course.

In selecting topics and emphasis, I asked; 1) What is of current interest, especially what are the new developments? 2) How can I make the course complete by adding Deep UV as well as E-beam and X-ray? 3) Which speakers were available, including people from the university so there could be university involvement? I selected one speaker from U.C. to cover the current-interest topics (Deep UV; compatible process); for coverage on E-beam; and to announce the UC computer program). Since more research goes on outside the university, it was important to get good speakers from industry.

Q. What instructions did you give speakers?

A. Each was given the 3 goals for the course, a brochure from a previous course, and an idea of the audience (i.e., 50% new, 50% experienced). Each was told to include everything they would say on a viewgraph so that all the information appears in writing.

Q. What have you learned about teaching this kind of course?

A. How to organize, that is, aim for a smooth presentation, break up the talks by subject matter, and use coffee breaks as dividers. How to prepare materials -- everything must be in writing.

Q. How is teaching an Extension course different from usual university teaching?

A. Preparation time is an order of magnitude longer because everything must be organized and in writing. The pace is faster because students are getting a one-shot deal and there are no rhetorical pauses for questions. The large size of the class also requires extra preparation.

Q. What special types of problems do you encounter in a course like this?

A. The wide range of background of the students is a problem.

Also how many questions to allow -- that is, allow clarification questions now, but postpone discussion questions until later. Questions may extend a talk for 20 minutes or more. Industrial speakers often feel that they can't talk about their work because it is a company secret. One must seek out open speakers and find researchers who are good speakers and vice versa. The class organization also has to be carefully monitored because 100 people have a tremendous amount of momentum so that a lunch that is 15 minutes late can be a disaster.

Comments: The Faculty Coordinator appears to have a good grasp of the range of knowledge and abilities of the students who took the course. However, in choosing to plan the course at a middle level (between basic and advanced and between applied and theoretical), he set up a situation that was frustrating to many of the participants who expected a more introductory class.

Recognizing the difficulties of planning and teaching a specialized course for engineers with such diverse experience (from the novice to the very experienced professional), the following recommendations are suggested as ways to improve the effectiveness of the course and student satisfaction without altering the basic course content.

1. Recommendations. Consider changing the title of the course to something other than "Fundamentals of HRL".. The most dissatisfied students complained that the course did not give them the fundamentals they expected while satisfied students were pleased that the course gave them a good overview of the field today. These latter students were more experienced, had taken more courses in the field and/or were working in areas peripheral to lithography and attended the course to improve their general knowledge. If "Overview of HRL" is not acceptable, why not just call it "HRL"?

2. Course Description. The course brochure should describe explicitly what the instructors expect that students should know in order to benefit from the course and the level at which the course is taught. Listing a reference or two in the brochure that students could read before taking the course would be very helpful for some students. (Others might not read the references before the course, but might be inspired to tackle them afterwards.) Although specifying the prerequisites more clearly would probably not discourage newcomers to the field from taking the course, it could reduce the number and intensity of the complaints of those who felt they had been misled by the course title and description.

3. Course Materials. Another frequent student complaint concerned the course materials. Each and every one of the 20 students interviewed 3-4 months after taking the course said that better materials would be more useful to them. Only two of those interviewed had used the materials as the instructor hoped -- to locate references to read... and even they complained that although the bibliography was helpful, the notes and viewgraphs should be more complete. Others found the notes useless -- that is, when they tried to use them to review several months later, they couldn't remember enough of the course to understand them. Nor were they able to share the notes effectively with others in their company. Even the authors of state-of-the art research books and papers discussed in the course and those who had taken this course before complained about the notes and suggested that the instructors provide "stand-alone" notes. Other suggestions were:

1) The notes should be a more complete outline of the lectures with the key terms and concepts given.

2) The view graphs should be identified more clearly with better labels and some explanatory text.

3) Pages should be numbered and the graphs and other aids should conform to the sequence of the presentations.

4) Taping the talks would help those who needed review to understand and remember the mass of information covered in the course.

Tapes could be sold to the participants.

If the goal of the course is to help participants update their knowledge and apply state-of-the-art concepts to their work, then providing good notes seems essential -- particularly if the participants are expected to share the information with others (or even convince their supervisors that they learned something from the course.)

4. Extending the Course (or adding more specialized courses.) Almost half of the participants indicated they were interested in taking a course in process modeling and several suggested that the course be extended to two days (with the second day optional) for a process-modeling workshop. An extended course might be tried experimentally to see whether participants are willing to attend a longer course. Others want more specialized courses on some of the topics covered in this course. (i.e., X-ray) Taking this course seemed to whet the students' appetites for learning and although they complained about some of its aspects, and felt that much of what was said was over their heads, most planned to take additional courses in the field.

5. Longer Coffee Breaks. One of the aspects of a short-course that is important to many participants is the opportunity to meet others in their field and discuss what they're doing, therefore increasing the coffee breaks by 5 minutes would enhance this opportunity and increase the value of the course for these students.* Also it would offer more opportunity for a few more participants to ask questions of the instructors individually.

6. A Simple Needs Assessment. To aid the instructor in planning the courses (as well as being a way to help the participants feel that their interests are being addressed), adding a short questionnaire to the class registration form in the brochure is an inexpensive and effective way to collect this information in advance of the course. Questions could be asked about previous courses taken, work experience in lithography, interests and expectations for the course, whether they knew of and/or had used SAMPLE, etc.

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*It's probably difficult to get students back into a lecture in 15 minutes anyway, so planning a slightly longer break in advance would ease the pressure on instructors whose talks otherwise might run over.

APPENDIX

[ ] [ ] [ ] [ ]

Follow-up Questionnaire - Composite Materials Workshop

N= 35

We appreciate your taking the time to answer these questions. Your response will help us improve our courses.

1. What is your present job title?

(See p. iv)

2. Your highest academic degree?

3 yrs. college(1); BA/BS(9); M.S.(16); Ph.D(3)

3. Year?

	#
41-45	1
46-50	0
51-55	3
56-60	3
61-65	3
66-70	4
71-75	6
76-80	9

4. What % of your time is spent in:

Average

[15%] managerial duties
[83%] technical duties
[2%] sales/marketing

5. Do you work primarily in:

% of class
[83] R & D
[11] Production
[—] Planning and Decision-making
[—] Sales/Marketing
[6] Other (specify) (1 teaching; 1 student)

6. How long have you worked in composite materials?

	1 yr.	2-5 yrs.	6-10	11-20	21-30
N=	14	13	3	2	2
%=	41	38	9	6	6

7-11. What were your goals in taking this course.

8. How well were they achieved?

% of total class	not at all	somewhat	very well
[74] updating technical information	[4%]	[52%]	[14%]
[89] knowledge of fundamentals	[34]	[52]	[14]
[31] perspective for decision-making	[6]	[61]	[33]
[57] meeting others in the field and finding out what they're doing	[—]	[70]	[30]
[80] improving job skills	[7]	[64]	[29]

Rate the course on the following:

12. pace [6%] too fast [94% about right [—] too slow
13. length [4] too long [85] about right [11] too short
14. difficulty [4] too hard [89] about right [7] too easy

Appendix (continued)

15. Have you been able to use any of the techniques or ideas from the course in your work? If yes, what and how?

Yes -- 51%

No or not yet - 41%

No response - 8%

(see comments attached p. iv)

16. Did you learn anything from the course that will affect your work in the long term? [82%] yes [12%] no If yes, what and how?

6% not sure

(see p. v & vi)

17. How would you rate the teaching methods used in this course?

% [31] excellent [57] good [9] fair [3] poor

18. What was the most valuable part of the course for you?

(see p. vi)

19. What was the least useful part of the course?

(see p. vii)

20. How would you rate the instructors' emphasis on the following?

	too much	about right	too little
fundamentals	[4%]	[81%]	[14%]
application	[–]	[43%]	[57%]
current research	[9%]	[25%]	[20%]

21. How did this course compare with other engineering short courses you have taken? (in usefulness, content, interest)

%	
[14]	the best I have taken
[31]	better than others I have taken
[29]	about the same as others
[0]	less satisfactory than others
[26]	have taken no others

22. Who initiated your decision to attend this course?

% = [60] you [34] your supervisor [6] selected by company

23. What one suggestion do you have for improving this course?

31 students gave suggestions (see p. viii)

Appendix (continued)

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No. _____
(area code)

[ ] prefer telephone interview
[ ] want further information
[ ] do not wish to participate

I do [ ] do not [ ] wish the information I give to be released to my company.
[ ] Please send me a summary of the final report.

Please return this questionnaire to U.C. Extension-XT37, 2223 Fulton St., Berkeley, CA 94720.

Q. 1. What is your job title?

Mechanical Engineer (2)
Research Chemist
Research Engineer
Research Fellow, Tires
Senior Engineer (3)
Technical Group Leader
Associate Dean of Engineering
Research Assistant
Project Coordinator (Sr. Research Chemist)
Engineer
Member, Technical Staff
Aerospace Tech. (Structural Materials Engineer)
Supervisor, Equipment & Test Unit, Laboratories
Research Analyst
Design Engineer
Re-entry Vehicle Design Engineer
Research Fellow
Consultant
Chemist
Research Scientist
Engineer III
Head, Office of Engineering Mechanics
Advanced Development Engineer
Task Leader, Ceramics and Glass
Manager, R&D
Senior Project Engineer

Q. 15. Have you been able to use any of the techniques or ideas from the course? If yes, how?

Stress analysis, calculation.

Computer programs in predicting composite properties.

Use knowledge of micromechanics and fatigue life of composite to modify the polymer research programs in selection of polymers for testing and in design of experimental programs for composites life prediction.

I am beginning to use some of the programs which were presented. Also, some of the ideas for testing with water absorption. Structural design for composite parts.

Calculator programs for determining laminate properties.

Basic understanding of strain calculations due to moisture effects.

Different design of a component on helicopter rotor blade. Gain understanding of rationale of composite design of wing of aircraft.

We are currently in a design phase where a composite material is proposed for a structural component. I needed this background to proceed with the design.

Concepts to stress to others that composites are not isotropic materials.

General atttitude--design of test samples.

I had been away from aerospace composite materials for 11 yrs. prior to last year. I have spent 20% of my time the last year advising our plaster lab on applications with more structural advantage. The course reinforces and updated my knowledge. I can now better understand composite material documents I read and broaden the plastic lab application knowledge.

Q. 16. Did you learn anything in the course that will affect your work in the long term?

I will be transferred to the R&D of composite materials. The course will be useful for this.

The theory will help in the design of chemcial service equipment.

Should help in our approach to composite design.

Strain and stress transformations and composite technology.

Reference materials; familiarity with T-59 calculator.

Basic understanding of viscoelastic effect and fatigue crack propagation, beneficial in current and future research.

In design for aircraft components in composites; select materials and composite structural design.

I met each of the instructors, know how to contact them, and may ask them questions in the future. I was greatly impressed by all of them.

The Tsai-Wu failure criteria in design of aircraft composite structures.

Moisture, creep discussions will allow us not to worry about these effects as much.

I need considerable study time to apply what I've learned.

Simple computational techniques using TI-59 calculator.

Strengthened fundamental understanding.

Methods for analysis of composite laminates to improve efficiency of composite structures.

Waiting for the go-ahead on some new programs.

Teaching and research activities will be initiated this summer.

Lack of understanding of molecular origins of failure of composite materials. Will put more research efforts in this area.

TI-59 methods.

Q. 18. What was the most valuable part of the course to you?

Mechanical properties.

Computer programs.

Fundamentals (3)

Dr. Tsai's part (4). The manuals and the calculator programs for calculating laminate properties.

Learning that we were already on the right track.

Dr. Springer's part.

Calculator programs, moisture absorption, micromechanics in that order.

Laminate properties programs.

Failure theory and application of the generalized Hooke's Law.

Practical applications of last afternoon.

Limited infm. on fire hazard with electrical equipment.

Exchange of infm. with others in the field.

Dr. Hahn's.

The broad-scope concepts and state-of-the-art ideas.

Viscoelastic effect, fatigue, fracture.

Getting a perspective from knowledgeable people.

Data and reference indicates composites still must be used with extreme care.

Practical aspects.

(***Every topic seemed to appeal to someone. The list above shows a great deal of variety of interests. However, here and in the interviews, the material covered by Tsai was much more popular than that presented by the other two speakers. Tsai's talk was focused more on fundamentals.)

Q. 19. What was the least useful part of the course?

Infm. on hydrothermal properties (Hahn)

Long eqns.

Part covered by Hahn. (3)

Parts relating to aircraft applications.

Micromechanics and theoretical models (2) (Hahn again)

Needed to use TI-59 programs on sample problems in class time.

Time spent on detailed use of TI59 calculator.

Static property calculations.

Any concepts not amenable to experimental verifications.

Description of Boeing activities.

Fracture mechanics was rushed, not given enough time.

Analysis of fatigue. (3)

Long theoretical developments that resulted in few conclusion.

Reports on inconclusive test results.

Less ivory tower, more practical--work some problems.

Laminate analysis.

Theoretical studies and derivations.

Everything else besides Tsai's part, because they did not reduce it to the simple form that he did, they did not have simple manuals like he did, and they gave their lectures on papers rather than teaching the material.

Q. 23. What one suggestion do you have for improving the course?

More Application

--Give more application data in the commercial sense.
--Less emphasis on theory, more on application (5)
--More emphasis on practical applications & testing--there was almost no time devoted to testing methods.
--Be sure that all programs are covered and that application problems are given.
--Add material on manufacturing processes, limitations, and the shop's effect on design.
--Spend minimum of 1 day, 2 is better, just working sample problems.

Materials

--Have all lecturers prepare manuals like Tsai's. Teach rather than participate.
--Provide texts on micromechanics, environmental effects, and fracture mechanics and time-dependent properties analysis. Also improve lecture techniques, particularly the micromechanics part.
--Suggest review of mechanics of materials and matrix methods before taking course. Have complete texts available.
--Better handout materials. (3)
--All viewgraphs should be available as handouts (2).
--Prefer to have materials before attending course.

Organization and Instructional Methods

--Too many subjects were touched on in too short a time. Cut a few out.
--More thought should be given to the introduction given before each lecture on what the speaker is trying to show or prove.
--Stick to generally accepted notations and standardize among instructors.
--A step-by-step design of some component would be helpful.
--Add section on latest developments in composite materials..eg., any new materials being investigated now, why, and how.
--It should be more concise.
--Break down course into two areas--advanced and basic topics-given entirely separately.

Information from Interviews.

How have you used informa ion/ideas from the course?

--Used in a NASA roject to develop and fabricate a windmill plate. The course gave knowledge of how to calculate laminated stress and calculation programs to calculate surface life at high pressures. I haven't changed procedures but have written proposal for changes and submitted it to my supervisor. The use of calculators will save us dollars by replacing use of full-sized computers. Tsai's presentation was really good..the best. Hahn and Springer's work is only of academic interest--I need more practical information. During the last day of the course, invite an engineer to present state of the art of composites in industry. The main benefit of the course was that I was introduced to how to do calculations of stress-strain in composites. I never learned this in school.

--Course gave me a good working knowledge of composites. Excellent information for future use, but our dept. hasn't much use for this. I would like to take further courses extending this with more applications--eg. buckling.

--Calculation of poisson's ratio using Tsai's notes. Tried to share with colleagues but this is tough unless the group had taken course..they're too used to homogeneous and isotropic materials. Tsai's presentation excellent but I didn't get as much from other people. They were more directed toward aerospace and got into design of wing for aircraft--too specific. Fifty percent of the course was of interest to me. Claremont Hotel was a good facility; beautiful view. Course could be improved if slides on actual tests were used and there were more discussion on significance of testing and its pitfalls. Need more emphasis on test than special applications. I'm not sure who course was aimed at. Wouldn't help to have notes in advance; people would just follow notes, not presentation. Half were not prepared anyway. Tsai's presentations were dynamic and handled well. Dr. Hahn was very well qualified but couldn't get points across in front of a group. He puts people to sleep by talking in a monotone. I talked to him on the side a couple of times. Tsai should take up 50% of program.

EVALUATION OF THE VALUE ENGINEERED DESIGN AND CONSTRUCTION COURSES

(Preliminary Report)

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Information in this report is based on questionnaires completed by 17 participants in the April 9-13, 1979 class, 8 follow-up questionnaires completed by participants in the November 1978 class, interviews with 8 participants, and an interview with Robert Mitchell, the course coordinator.

The material in this report is based on work partially funded by the National Science Foundation under Grant. No. SED-78-22138. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the author and do not necessarily reflect the views of N.S.F.

What is VE?

Value engineering is a procedure to reassess the economic viability of a project previously planned or designed. If the project is currently in its initial design stage, value engineering aims at saving money. As an example, consider the construction of a concrete channel for a river bed or aqueduct. Conventionally, one builds a frame for the sides and pours concrete to form a vertical slab. A value engineering approach might find it more economical to pour a horizontal slab and lift it into the vertical position.

There is a certain methodology/approach to design/way of thinking which is called value engineering and which consists of a specific series of questions which one follows in assessing one's project. This is what is taught in the week-long workshop.

Description of the Course

The Value Engineered Design and Construction course is a 40-hr. workshop organized and taught by Mr. Robert H. Mitchell, one of 175 Certified Value Specialists (CVS's) in the United States. The Society of American Value Engineers (SAVE) of which Mr. Mitchell is a Regional Vice-President, certifies CVS's and approves the training workshops that they teach. While the Value Engineering (VE) methodology is fairly standard, any course outline approved by SAVE may be used in the 40-hour training session. The training may be geared to a specific discipline -- this one focuses on design and construction applications-- or to more general engineering problems. Participants who complete the workshop are certified as eligible to become members of a Value Engineering team (described below). There are many additional requirement for CVS certification including the stipulation that fifty percent of one's working hours be spent in performing value engineering analyses. Thus most participants in this course will continue to gain experience in VE by working on VE teams, but will not go on to receive CVS certification.

The client of a design or construction firm may require that a VE study be done in addition to conventional design procedures. The VE analysis is a separate budgetary item and may be subcontracted to a VE consulting firm. The team leader for the VE study must be a CVS so if the study is not subcontracted, the firm usually has to hire a CVS leader.

The leader may require the remaining four to six members of the team to complete a 40-hour VE training program. Members are usually selected by discipline (that is, mechanical engineer, electrical engineer, architect). Sometimes the client requests that the team exclude anyone who has previously worked on the design project.

Private firms that operate on a profit-loss basis have typically been most interested in the cost-saving and efficiency results of VE. However, government agencies are showing increased interest in VE, and some agencies require that a VE analysis be done on larger construction grants. (Note:

The federal government's increased concern with VE may be reflected in a difference between the November '78 and April '79 classes-- only one participant in the November class identified himself as working for the government while 47% of the April class reported that they worked for a governmental agency.)

Course Goals. The goals of this course are twofold: 1) to train engineers in value engineering and 2) to enable companies to save money. The payback to the client of a VE study is usually much greater than the cost of the study and of training the team members.

According to the instructor, students who take the course benefit by gaining an increased potential for satisfying clients, a chance to establish personally a new profit-earning center within their companies and increase their success, prestige, and opportunities for promotions. The company gains similar benefits: new profit centers, new ways of thinking for employees so that they do a better job, higher work satisfaction among employees, and more clients.

Methods and Instructors

Mitchell uses the Learn, See, and Do method of instruction-- that is, lectures, films, and teamwork. Students learn by doing-- that is, through participating in a workshop project that they may bring in themselves or a "real-life" project that is assigned by the instructors. Team study is emphasized and teams are organized on the first day of the class to build student interest. Also, Mitchell intersperses lectures with team sessions so that students can apply the ideas they have just heard and absorb the new material better.

Mitchell divides the VE system (and the course) into five phases: 1) information, 2) speculation, 3) analysis, 4) development and 5) presentation and follow-on. The class participants role-play different specialists (architect, contractor, construction engineer, etc.) as the teams work through each phase. Mitchell uses only Certified Value Specialists as instructors and tries to be personally involved in at least two workshops per year to observe the quality of the instruction. He often lends course materials to other CVS instructors.

Students and Their Problems. A week prior to the start of the course, students are sent the text and a list of related publications. Mitchell states that they tend to arrive at the course somewhat emotionally upset and apprehensive because value engineering methods call into question conventional design procedures. Most students are practicing engineers or other professionals, but a few are supervisors. Most higher level employees, that is, managers or executives, attend four- to eight-hour VE seminars that introduce them to the concept of VE but do not certify them to become a member of a team.

Some students come on their own initiative; others are preparing to work on a VE team for which they have already been chosen.

Mr. Mitchell states that the course may cause problems for students because it requires them to change their fundamental beliefs. In performing a VE study, conventional designs may be questioned or discarded and clients' criteria and requirements for a project may be challenged. Students learn that twenty percent of one's design efforts account for 80% of the cost. This means that they must continually be open to new knowledge and must accept the idea that they must always be reeducating themselves. Also, they learn to ask questions, both within the workshop and on their jobs, even when it means doubting the conclusions of their supervisors.

Methods

Questionnaires were administered to the 17 students who took the April '79 course during the last day of class. Also 8 out of the 11 participants in the November 1978 class returned follow-up questionnaires mailed to them five months after the course ended. Seven students (6 from the '79 group and one from the '78 group) were interviewed by phone three to six months after they had completed the course.

RESULTS

Student Evaluations of the Course

Students gave the VE course positive ratings in comparison with other engineering short courses they had taken. Only one respondent said that he felt that it was less satisfactory than other courses. The '79 class was somewhat more positive about the course than were students in the '78 group.

Q. How did this course compare with other engineering short courses you have taken? (in usefulness, content, interest)

'78	'79	
13%	11%	the best I have taken
38	53	better than others I have taken
38	24	about the same as others
13	0	less satisfactory than others
0	18	have taken no others

Most of the students from each class cited "learning methods for economic evaluations" and "reducing design and construction costs" as their goals in taking the course and indicated that they were "very well" achieved. Some checked "receiving a certificate of participation" and some checked "finding specific design alternatives"-- a goal the group

felt was only "somewhat" achieved. Responses to this latter item seemed to be influenced by whether the student's project had been selected for team-discussion. That is, 8 of the participants in the '79 class brought projects, but only 4 were used in the workshop. Those people whose projects were chosen felt the course served them very well; those whose projects were not selected were less satisfied.

Q. What were your goals in taking this course?			How well were they achieved?					
# responses			not at all		somewhat		very well	
'78	'79		'78	'79	'78	'79	'78	'79
4	10	finding specific design alternatives	0	20%	100%	50%	0	30%
6	15	learning methods for economic evaluations	0	0	28	20	79	80
7	16	reducing design or construction costs	14	0	43	31	57	69
4	13	getting a certificate of participation	20	15	40	15	20	70

Participants gave high ratings to both the team workshops and lectures although more students in the '79 class judged the lectures to be excellent than did those in the '78 class. On the average, both groups rated the films as "good" although several students complained that they were out-of-date.

Q. How effective were the various forms of instruction?

	poor		fair		good		excellent	
	'78	'79	'78	'79	'78	'79	'78	'79
team workshops	-	-	12%	18%	38%	29%	50%	53%
films	-	-	12	18	63	59	25	24
lectures	-	-	12.5	6	63	44	12.5	50

The 1978 class rated the instructors' emphasis on fundamentals, application, theory, and current research as about right although several students felt that there was too little emphasis placed on current research.

Q. How would you rate the instructors' emphasis on the following?*

	too much	about right	too little
	'78	'78	'78
fundamentals	12%	88%	0
application	0	88	12
theory	0	100	0
current research	0	63	37

*This question was not included in the questionnaire given to the '79 class.

Summary. The students surveyed in these VE courses were more satisfied with the course and gave it higher ratings than did students in the 9 other CEE courses we evaluated. Even those who felt the course content was "basic common sense" considered the class experience was worthwhile (with one exception.)

The Satisfied vs The Dissatisfied Customer-- Examples

Data from interviews with two of the students with similar backgrounds, but diametrically opposed attitudes about the course, provide interesting insights into some of the factors affecting students' acceptance of the course. Both students completed their bachelor's degree almost 30 years ago; one designs steam plants, the other designs sewage disposal plants. Neither are government employees. Both stated that they had always used VE princiles informally in their work, although they were not familiar with VE terminology and methods until they took the course. The satisfied student's project was selected for the team workshop; the dissatisfied student did not bring a project, however, other factors may account for their attitudes toward the course. The dissatisfied student did concede that the course could be beneficial for others, but not for him.

Case A.

A structural engineer with 28 years experience in construction rated the course as the best he has taken. Although he had not previously studied VE, he has taken a great many UC, CEE courses on other topics. He felt that the VE course met his goals of learning methods for economic evaluation, and reducing construction costs very well and was somewhat satisfied in learning how to find design alternatives. He described the instructors as excellent, interesting, and very knowledgeable, thought the lectures and team approach were excellent, and the films good.

He said that he was familiar with the principles underlying VE and had always used VE informally-- though not according to this method, but felt

the course was very worthwhile. As a result of taking the course he has changed his approach to design-- becoming more analytic, using more brainstorming, and considering more options in a design. His project was discussed in the workshop and he feels he profited from this .. although his recommendations were too late to be incorporated in the design of the plant.

He liked the length of the course and its focus on real-world problems especially since "you got involved in the problem and stuck with it for a week."

He felt the course gave him a tool to use plus a reference, based on an accepted system, to support the conclusions he would make in terms of any project. He added that he felt the course would benefit managers as well as the practicing engineers who took it. His one criticism was that he thought the instructors should stress the difference between the points that are to be used as givens with little or no change vs. those that are suggested, but where variations are optional.

Case B.

The student who was most negative about the course rated it as less satisfactory than others he had taken, felt his goal of reducing design or construction costs was met not at all, and recommended that his company not send other engineers to this course. A senior engineer with 29 years of experience, he said that he had no specific knowledge of VE methods before taking the course, but found that he and the others in his company were routinely using VE methods in their work. In designing a project, he and his colleagues search for cheaper ways to do things according to function. So he felt no need to change as a result of taking the course. He does not need a VE certificate and is not working on projects that require VE analysis per se. He did concede that the course would be of great benefit to practicing engineers who did not stress these ideas in their work and suggested that it would be good to give a similar course for process designers and show them how VE can affect a process in which you are working with a given piece of equipment rather than designing the size of a window. He felt that the course instructors ranged from excellent to good and knew what they were talking about in terms of content. He rated the team workshops as good, and other aspects of the course as fair.

Expected Applications and Impact of Course on Job

The majority of the students in each class had applied or planned to apply VE principles to their job duties and half of the '78 group had encouraged their colleagues to take training and their companies to apply VE to all of their projects.

As a result of taking this course, I (plan to) or (have):

'78	'79	
13%	24%	taken additional training in V.E.
50	24	encouraged my colleagues to take VE training
50	41	encouraged by company to apply VE to all of their projects
63	88	applied VE principles to my job duties

Of the five workshop phases-- information, speculation, analysis, development, and presentation, most students checked analysis as the one that was most immediately useful. However, the majority of the students in both classes indicated that they could use all of the phases immediately (or had used them). Development and presentation were most often cited as being useful in the future. Two persons saw the phases only as useful to them in the future.

Which topics (will be) or (have been) most useful to you in your work either immediately or in the long-term?

	Of immediate use		Will use in future	
	'78	'79	'78	'79
Information	100%	76%	43	35
Speculation	86	56	43	29
Analysis	100	88	43	24
Development	57	71	86	41
Presentation	51	59	86	53

(Briefly described the ideas and techniques you found most valuable and how you used them.)

The seven engineers who were interviewed three months after completing the course were using VE principles in a variety of projects. Even those who had not been able to convince their companies to adopt VE formally said that the ideas gained from the course helped them in their own work (indeed some said it changed their lives.) (See Appendix for summaries of these responses.)

Suggestions for Improving the Course

Ten students gave suggestions for improving the course:

projects (getting more information about how projects were selected and what to bring in, etc.) -- 4 responses.

films (need updating) 2 responses

more emphasis on economic analysis (life cycle costing, etc.) 2 responses.

other (see Appendix)- 2 responses.

Company Support for the Course

Students in the '78 class were more often chosen by their supervisors or companies to attend the course than were those in the '79 class where the majority came on their own initiative.

Q. Who initiated your decision to attend this course?

	'78	'79
I did	13%	53%
Supervisor	49	35
Selected by Co.	38	24

(some students checked more than one alternative)

Companies paid full or partial course expenses for all the students surveyed. Although the course coordinator indicated that VE training would improve possibilities for promotion, only one person checked this alternative. Perhaps students are not yet aware of this potential, or are reluctant to check this response (i.e., it may suggest unseemly ambition.)

Q. How does your company support/recognize attendance at courses like this one?

'78	'79	
25%	-	company strongly encourages attendance
88	94%	company pays fees and expenses
50	24	company grants released time (time off)
0	6	course attendance increases possibility of promotion-raises/
0	0	no particular encouragement
-	6	other (specify) Co. pays part of costs.

(some students checked more than one alternative)

None of the participants said they were required to have VE certification to hold their present positions, but four anticipated that VE certification would be required soon.

Educational Background

Most of the participants had bachelors degrees with only 3 holding master's degrees. Most completed their formal education more than 20 years ago.

Q. What is your highest academic degree?

	Nov. '78		April '79	
	N	%	N	%
H.S.	-	-	3	18
A.A.	-	-	-	-
BA/BS	5	21	13	76
MA/MS	2	29	1	14

Year graduated?

	Nov. '78		April '79	
	N	%	N	%
1948-55	2	40	8	50
1956-60	2	40	2	13
1961-65	-	-	0	-
1966-70	-	-	5	31
1971-75	1	20	1	6

Work Experience

Students in the '78 class more often identified their primary work as design while those in the '79 class worked primarily in engineering or construction management.

Q. Do you work primarily in:

Nov. '78		Apr. '79		
N	%	N	%	
6	75	6	38	Design
1	12.5	7	44	Engineering
-	-	4	25	Construction Management
1	12.5	5	31	Other

Most of the students in both classes had worked more than 10 years in their present specialties.

Q. How long have you worked in your present specialty?

	Nov. '78		April '79	
	N	%	N	%
1 yr.	1	14	5	29
2-4 yrs.	1	14	2	13
5-10	2	29	5	29
11-24	2	29	0	0
25+	1	14	5	29

On the average, particpants spend about 25% of their time in managerial duties, 57% in technical and 8% in marketing/contracting. Two are full-time managers (spending more than 90% of their time in administrative duties and 4 are full-time technicians.) Most of the group, as befitting their experiences, supervise others (ranging from 1-10 employees.)

Conclusions

This course was the most successful of the 9 CEE courses we have evaluated in both satisfying students and in influencing their behavior on the job. Those who took the course were very positive -- indeed enthusiastic-- about the format, teaching techniques, quality of the instruction, and the applicability of the ideas they learned. Follow-up data suggests that even when they were not able to use the VE methods formally, they were applying the ideas to their own design projects and daily work. Students who took the course expressed greater confidence in their ability to solve design problems-- a feeling of efficacy (that is, a stronger belief in their own professional capability.)

What is surprising about these results is that the students were practicing engineers with many years of experience. They were undoubtedly veterans of many CEE courses and most had not taken graduate work so that one might expect them to be a bit jaundiced about taking CEE courses.

The interaction of a number of factors seems to account for the success of the course. First of all, the students were a relatively homogeneous group (in comparison to most CEE courses) in regard to educational background, interest, and experience. Second the small classes, team workshops, real-life projects, and the course content itself maximized the conditions for transferring the ideas learned. Third, the instructors were viewed as both knowledgeable and effective.

Recommendations

1. Several students complained that they needed more explicit instructions about how to prepare projects so they would be selected for the team sessions and the criteria used in selecting projects. They expressed disappointment that their projects were not chosen and felt that had they known what was expected they would have brought more background information to the class. However, in our opinion, the description and criteria presented in the April VE Course brochure are very explicit and clear. It may be that prospective students do not always read the course brochure, and we are not sure how that might be remedied. (Or maybe they read an old brochure.) Perhaps sending out another copy of the project information with the materials sent to the students in advance of the course might help, if this is not already being done.

2. If it is essential to use vintage films in the course, then the instructors should consider ways to explain this so students will find them more palatable. Students reject films that are dated and may miss their messages.

3. Some participants will inevitably be disappointed because they seek simple answers to complex questions and find that the instructors do not (and perhaps cannot) tell them precisely which alternative is best or how to determine the best among an array of possible alternatives. Perhaps the instructors could emphasize the importance of the negotiation that inevitably goes on when group decisions are made. It would help students if they would point out and discuss the struggles that occur during team decision-making.

Other than these small points, we recommend that the instructors keep on doing what they are doing. It seems to be working very well indeed.

APPENDIX

Q. Describe the ideas and techniques you found most valuable and how you plan to use them:

(April 1979 Class-Questionnaire)

(10 responses)

Functional Analysis (4)

-- Functional analysis; use in design and construction; possible environmental.

-- Functional analysis of elements. These techniques will be used on highway construction projects and resource conservation studies.

-- Found the idea of functional analysis most valuable.

-- The identification of function followed by examination of alternative solutions in an organized manner. I am going to encourage staff members to use this approach in planning new work.

Overall Course (3)

-- This short "40 hours" course is most valuable. An excellent approach to the following: 1) the today inflation and 2) very educational approach in human relations, not only for professionals but in general daily life. The melody of a song makes a person happy, so a good approach will be awarded. The late Ghandi once said: "One friendly word can carry fruits tomorrow."

-- The entire program of value management will be utilized on our in-house projects, both design and construction. Anticipate doing VE work for present and future clients.

-- Formalized methodology for the gathering and analysis of information for both original design and review of existing construction.

Other Aspects of the Course (3)

-- The technique of eliminating the apparently important criteria and zeroing in on the main REQUIRED criteria is the most valuable idea.

-- Speculation--I will try several different ways to do the job, and yet perform the basic function.

-- The most helpful is the process. Also, the course was a great motivation to me to spend more time on the process. I would like to work on a VE team to get some practice.

(Follow-up Questionnaire Nov.'78 class)

-- Techniques used.

- comparing alternative structural systems, building skin materials using a matrix for relative ranking.
- identifying and concentrating on primary function to avoid getting sidetracked by peripheral or irrelevant issues.

-- Reviewing a project at early stages to determine cost and system alternatives.

(Follow-up Interview Responses)

Q. How have you used the ideas/information presented in this course?

-- I have been reviewing sewage treatment plant design and my project was discussed in the workshop. I made recommendations that were too late to be incorporated in the design. I discussed the course with director and assistant and gave them the course notes. In my own work, I am analytic in my approach, use more brainstorming and consider more options in design.

-- I've used it on a small project in an informal way--a small retrofit for air conditioning in two equipment rooms in a hospital. Asked did they need air conditioning, etc; what sort of down time, etc. (anticipated complete retrofit of system with some down time; instead they suggested adding a unit without losing service time). I've issued an office memo about the course and VE techniques and mentioned it in a committee meeting. In my personal work, I changed to using terminology and method in dealing with clients and colleagues (asking what the building is supposed to do.) I've used the notes to check on questions raised and approaches, and to review phases of the VE method.

-- I hope to use VE soon in work for A.C.E., possibly for the Air Force Base. Have shared information with colleagues although some of them have taken the course before and have membership in the Society of American Value Engineers. I've not changed procedures because most of the staff apply VE subconsciously in designing structures. Have used the notes once or twice to keep acquainted with the material. Do not plan to use procedures per se, but will edit them.

-- I've used the ideas on a project at Vandenburg Air Force Base for a space shuttle--considered the electrical aspects. I shared ideas with colleagues and supervisor very briefly, and told them that it was a very good course, one of the best I have taken. Before taking the course I would just use a standard method to select a switchgear; now I look at the function and recommended a less costly switch gear that performed the same function. Also there were things that were not needed in a design--for instance, a lightning protection system (there's no lightning hazard in Cal.)

-- Having taken the course, may awareness has changed. I'm more conscious of $'s. My office is working on a hospital design project for which we will be doing a VE analysis soon. I'm pushing colleagues to use VE in the hospital project and recommended that they take the course. Since I work for the government, any project over $2 million must have a VE analysis done, so there is no choice. The individual can't change the process. Have used the course notes to get an overview of the process when I was pushing for the VE analysis of the hospital project.

-- The project studied in the course has been submitted for approval--a roadside rest project. Figure we've saved $10-15000 on a $2-3 million dollar project. Have made some smaller recommendations on road construction projects resulting in $10-12,000 savings from changing shape of culverts, slope of adjacent land, etc.

-- I've no control over whether VE analysis is done in company. The VE team coordinator chooses the projects for VE analysis. I have discussed the course, the project studied, and conclusions with my supervisor. Have used the course notes to refresh my memory, and to look up procedures when attending meetings on the roadside rest project.

-- Yes I've used them--qualified by the fact that I have always used VE in designing power plants. Part of design is to look for cheaper ways to do things and to design according to function.

Q. What one suggestion do you have for improving this course?

(10 responses) (April 1979 Class-Questionnaire)

Projects (4)

-- Better review of projects.

-- More advance information as to what is expected in the course. i.e., needed much more reference material to properly evaluate design of project. Would have brought it if I had known.

-- Better selection of projects.

-- Need to bring more information into the classroom with us.

Films and Materials (2)

-- Update films ASAP.

-- Update films and samples. Improve quality of printed matter.

More emphasis on economic analysis (2)

-- More emphasis on importance and procedures of economic analysis.

-- More explanation and instruction on life cycle costing.

Other (2)

-- The team workshop--I think that more time is required to investigate and analyze the project being VE.

-- Stressing those points that are to be used as given with little or no change, and those that are suggested ways but variations are optional.

Q. How much did you know about the topics covered in the course before you took it?

-- quite familiar--28 years in construction. I've always used VE informally, but not according to this methodology.

-- very minimal except what I'd heard about the course itself.

-- Architects do VE naturally...consider how you choose material for building. I can't see much difference between common sense and VE.

-- I was not familiar with the approach to VE problems but was aware that other ways to approach a problem exist in order to cut costs, but not aware of the approaches.

-- I was familiar with the ideas from a previous course as I had taken a 40-hr in-house workshop.

-- I had read some literature and the reading suggested for this course. Prior to taking the course I had been assigned to a VE team.

-- Had no specific knowledge of the VE method.

Q. How do you feel about your knowledge of VE now?

-- I feel the course was very worthwhile.

-- Feel my knowledge has increased considerably.

-- Have not had much opportunity to practice, hope to use it soon.

-- Feel I know 85% of what there is to know about VE.

-- The course was worthwhile reinforcing information learned in other courses, but the specific approaches were a little different--i.e., the Information Phase had not been included in previous course.

-- The course was worthwhile although I haven't felt a lot of results. It's hard to change designs and get changes approved by the original designer.

-- No change in knowledge as I was already using the ideas presented in the course.

Q. How do you feel about the instructors' presentations?

-- Very competent; could have put more emphasis on mechanics of economic analysis or suggested where to learn this information--perhaps from another course.

-- Excellent instructors compared to those in other courses I've taken.

-- Excellent--very understandable.

-- Did their job adequately as monitors for this course. What you get out of the course depends on the activity of the team you're assigned to. Mine had top-notch, enthusiastic people so it was excellent. But instructors did their job adequately.

-- Very good. This was one of the better courses I've attended. Both of the instructors were very enthusiastic which made the course go over very well.

-- Mitchell--excellent; Kelly-good (in some cases he appeared to be talking from rote). Content: Both knew what they were talking about.

Q. Was the content of the course focused on the needs of practicing engineers? If not, how might it be improved?

-- Yes, largely because of the workshop approach. Instructors should bring in projects and assign them to groups. Some people were too involved with own project because they had designed it to be able to criticize it adequately. My group was divers; and unfamiliar with the project so this was good.

-- It's not possible to do this in a 40-hour course. Should be offered differently for people with different levels of experience.

-- Yes, it was appropriate. I would like a longer study period to work on an actual job. Workshops were good, but we needed more time to study the problems and more discussion of finances--how to make a cost statement. --More options than I expected; need explanations on when to use each.

-- Yes--but instructors could have monitored the workshop group activity more actively. There were disagreements within the group that instructors might have helped to arbitrate and resolve.

-- Yes. It's hard to change your concept into VE, to consider function analysis rather than cost analysis. Need practice--5 days in a classroom is not enough to make that switch, but can think of no better way to learn/teach the VE method.

-- Yes, depending on the type of engineer. If the engineer did not normally stress these ideas in his work, course would be of great benefit.

Q. What were the main benefits of the course to you?

-- First, I obtained the VE certificate; my office now can accept government projects. Second, I've learned a very good design approach which I've spread to other workers in my office.

-- To serve clients who think there is value in the service and to serve the public (taxpayers) money especially in an inflation economy. (We do government projects.)

-- Opened my eyes to these concepts. I always took the standard methods for granted. Now I question them and use a functional approach in design. An excellent course, I was very surprised.

-- I got an appreciation of VE and the principles which carry over into fields outside my own. It is a general problem-solving methodology that can be used in everyday life.

-- The course got me thinking in a different direction. What does a design do rather than what does it cost?

-- Don't feel I got any benefit from the course because I was using the principles routinely. The VE certificate was not needed as I am not working on a VE team or on projects that require VE analysis per se.

-- Gave me a tool to use plus a reference to support the conclusions I would make in terms of any project. Course is good for the management level as well as the engineers who took the course.

EVALUATION OF THE ELECTRON-BEAM LITHOGRAPHY COURSE OFFERED BY CONTINUING EDUCATION ENGINEERING U.C. EXTENSION AND THE COLLEGE OF ENGINEERING UNIVERSITY OF CALIFORNIA, BERKELEY

November 27, 1978

(Professor T. E. Everhart, Faculty Member in Charge)

Evaluators: Martha Maxwell, Ph.D.,
N.S.F. Project Director

Carolin Showers, M.S.
Research Assistant

Electron-Beam Lithography is an intensive, one-day, state-of-the-art course with the purpose of presenting both the advantages and disadvantages of direct electron-beam fabrication, with enough fundamental background material that attendees will be able to decide for themselves whether direct electron-beam microfabrication should paly a role in their future production plans for high performance integrated electronic circuits. The faculty-member in charge, Thomas E. Everhart of U.C. Berkeley was assisted by three speakers, Alec N. Broers of IBM Research Laboratory, Hans Pfeiffer of the Electron Beam Technology Group of IBM, and Larry F. Thompson of Bell Laboratories. The topics covered in the course included fundamental aspects of electron-beam lithography, direct electron-beam exposure systems, electron-beam resist and processing considerations and opportunities in nanometer fabrication. A panel discussion was held at the end of the day where all speakers were available to answer questions from the audience.

This report is based on the responses of 54 course participants to follow-up questionnaires sent six months after the course ended and on phone interviews with seven participants. Since only 50 percent of the participants in the class returned questionnaires, the responses received may not be representative of the total class. Therefore the results should be interpreted with caution.

Student Characteristics: The participants in this short-course ranged widely in educational background, experience in the field, positions held, and interests. There was a fairly even division among those holding Bachelor's, Master's, and Doctoral degrees. They received their last degree over a 25-year span with the majority graduating after 1965. This class seems less involved in technical duties and more concerned with administration than is typical of participants in other CEE courses. The average respondent spends about a third of his time in managerial duties, 61% in technical, and 5% in marketing. Over half of the respondents spend more than 20 percent of their time in administrative work while a third devote more than 90% of their time to technical work. Most participants work in research and development with a small percentage in planning and marketing (12%) and production (8%). Respondents indicated their experience in lithography ranged from none (20%) to more than 5 years' (29%).

This project was funded by the National Science Foundation under Grant # SED-78-22138. The opinions, finding, conclusions, and recommendations expressed are those of the authors, and do not necessarily reflect those of the National Science Foundation.

Evaluation of the Electron-Beam Lithography Course,

Student Evaluations

Most people enrolled in the course to update their technical information and the majority reported that the course was successful in this regard. Those who wanted to learn fundamentals or acquire perspectives for decision-making were somewhat less satisfied with the course. Generally, participants felt the pace of the course was about right and only three people complained that it was too slow. The average respondent rated the instructors' emphases on fundamentals, applications, theory, and research as "about right." About a quarter felt there was too little emphasis on applications, 18% wanted more theory, and 9% would have liked more research. Overall, students were satisfied with the course ranking it as somewhat better than other CEE courses they had taken. Two said it was the best course they had taken, and five rated it less satisfactory than other courses.* Twenty-two percent said they had taken no previous courses in lithography.

Forty percent of the respondents found something in the course that they could use immediately on their jobs, and a slightly higher percentage felt information learned about topics in the course would affect their work in the future. About a quarter of the respondents reported that they were using ideas or information from the course in their current company projects while 40% had done additional individual research. Twenty-three percent said they had done nothing further with the information. Ten percent of the group had enrolled in other lithography courses while the majority had discussed the course content with their colleagues and 43% had discussed it with their supervisors. Most reported that the course materials were useful, although a few felt them to be of no value.

Most respondents felt the course had benefited them professionally and that their companies had gained "somewhat" from their attendance. All but three of the group said they would recommend the course to a colleague.

Twenty-four people made suggestions as to how the course might be improved. The most frequent suggestion (n=12) was that the course be made longer and/or that topics be covered in more depth (i.e., more fundamentals, more application, more time for informal discussion, etc.) Six people made suggestions about the course materials (better materials, send handouts out in advance, etc.) A few commented on instructors, organization, and other topics.

The following summaries of some of the interviews illustrate how different participants view the course.

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* An analysis of the 5 dissatisfied students showed that all agreed that there was not enough emphasis on applications. Three had taken the course before and found nothing new. Two wanted more depth. Two found the notes worthless and one felt that IBM dominated the course.

Evaluation of the Electron-Beam Lithography Course,

Interview Summaries (E-Beam Course)

#1 An engineer manager in process development who supervises 7 people, has an M.S. and 8 years experience in the field.

He felt quite familiar with the topics before taking the course, but had no hands-on experience with the equipment. After the course he felt more confident as he now has source material for understanding the different types of machines and their uses.

Prior to the E-Beam course he had attended a Kodak Seminar and has gone to the SPIE Conference since taking the E-Beam course.

He presently is involved in a planning effort of an affiliated group in making a decision to purchase an E-beam machine. He felt the most relevant part of the course was on process- types of resist, and has been helping the group by contributing information he learned in the course on this topic.

He has used the course notes/materials for reference and for deciding to purchase a machine.

He felt the E-Beam course instructor's presentations were very well done, but assumed some prior knowledge. (He is not a user in the field and would have liked and needed a presentation on fundamentals). He felt all three speakers were well-prepared and gave good presentations.

He recommended that the course might be improved with a 1-2 hr. presentation on fundamentals and felt that Everhart's overview lecture was oriented toward state-of-art rather than an introduction to E-beam. (Commented that Everhart was an excellent speaker.) He suggested that an additional day would have been good with the first day spent on fundamentals and the second on state-of-the art information.

He felt that the main benefit of the course was that it exposed him to the state-of-art in both machines and processing techniques but he considered the discussion of capacity for E-beam was somewhat esoteric since these potentials are not yet developed.

In general, he was reasonably satisfied and felt he had learned a lot from the course.

#2 A company president who spends half his time on technical duties, supervises 7 people and who received a B.S. some 25 years ago.

His company is working on developing their own E-beam resist amoebus unit (a production machine) and he took the course to update his technical information (finding it somewhat satisfactory for this) and to increase his knowledge of fundamentals (and was well satisfied in this.)

Evaluation of the Electron-Beam Lithography Course,

Prior to taking the course, he had practical knowledge and as a result of the course he feels much better about his background--he learned of the state of the art and met other people and learned how they are thinking.

He's taken no other courses in this field and attended this one because it was held at the airport which is close to his company.

He has used the information from the course to look up patents and other work, to get in touch with researchers in testing and R&D, and to set up replication experiments. His interest is the chemical development of photo resist and is limited to building the instrument itself. He hasn't changed procedures and is still in the process of checking other people's results. He gave the course materials to those in his company who will direct the project for new ideas in chemicals and for replication of experiments.

He felt the instructors were all good. The Hughes and Bell people spoke on topics most relevant to his work. He felt that the others were well-qualified and interesting although he did not pay attention to their presentations per se, he did not fall asleep either.

He recommends that the course be spread over a two day period with more on the chemical and application techniques of resist. He felt there was too much on the equipment (design, and idiosyncracy). He's just interested in the product and doesn't need to know how the machine makes its product.

The main benefit of the course to him was that it exposed him to information on chemicals that have been tested, evaluated, and developed for use in photo-resist.

#3 A MTS with a M.S. degree who has been in lithography 2 years. He said that his work is primarily technical and he uses the E-beam process to fabricate devices. Prior to taking the course he was not familiar with optics nor how the E-beam machine works and said the course gave him a broader picture of the basic background of E-beam research. He has taken no other courses in this field. After the course he tried to apply the idea of developing resistor profiles as a function of the energy of the electron beam. The results matched those described in the lectures but were not precise enough for what he needed. He says he has reviewed the notes from the course, sent some memos about it to his colleagues and given them the course notes. He has not had much chance to use the ideas from the course as yet. He thought the instructors were very good but felt they should go deeper into optics, E-beam resist, and fabrication--for him the material was too basic. He liked Everhart's presentation best as he's taken courses from him. Considers Thomas and excellent speaker who gets the audience's attention.

He feels the course was probably intended to present more background information than to give ideas for immediate application and suggests that a two-day course would be more adequate--the first day could stress background and the second present detail.

Evaluation of the Electron-Beam Lithography Course,

He felt the course benefited him because it broadened the E-beam lithography picture and gave him the fundamental physics necessary to understand it.

#4 The president of an investment company. He took the course because he was interested in the future of two companies and wanted to learn whether they were keeping up with the state-of-the-art. A former philoscphy major in college, he said that 2/3 of the course was over his head, but that he was well satisfied that he got what he wanted out of it. Immediately after the course he met with one of the other participants and was tutored--got his questions answered and the language and concepts clarified. He observed that one of the companies that he was interested in sent five participants while the other only sent one so he called the president of the board of the latter company and arranged a meeting. He and the board president then met with the company president and the director of the lithography section and quizzed the director. He said that as a result he was satisfied that this company was keeping up with the field even though they only sent one representative to the course. He felt that the course helped him to learn the vocabulary and the right questions to ask and cleared up a lot of the misconceptions he had about the field.

#5 A Ph.D. with university teaching experience who is the lead person in E-beam lithography in his company, but who has only had 6 months experience. When he took the course he knew nothing about E-beam, but was very well prepared in physics and chemistry, and feels that the course increased his knowledge, and familiarized him with the field. He said the course was very valuable as an introductory course, but was not state-of-the-art as it was too low-level, and did not delve deeply enough into topics. He felt the instructors presented the material very well and suggested no improvements. He felt the course prepared him very well for summer conferences and that the timing of the course was good. The reprints handed out were helpful as they directed him to reference material.

Recommendations

This course appears to be about as good as it can be considering the constraints of time (one day) and the various needs of those who attend it. Participants rank the course as better than other CEE courses they have taken and, in general, are satisfied that it meets their needs in updating their knowledge. However, there appear to be some strong reasons for trying longer, perhaps two-day courses that would meet some needs that are not presently being addressed. A longer course would benefit those participants who need more intensive explanations of fundamentals and help in applying the concepts to their specialized situations, if an extra day of workshop/discussion sessions were offered. Those people who have taken the course before or those who are experts in the field might be better satisfied if they had more opportunities to exchange views with other participants and with the instructors. If the course were longer, sessions of particular interest to the more experienced lithography engineers could be included.

[ ] [ ] [ ] [ ] (1-4)

E-Beam Lithography Course Questionnaire

(54 Questionnaires returned out of 108 sent.)

Please fill out the following items carefully. Most questions can be checked, but a few require short answers.

We appreciate your taking the time to answer these questions. The information you give will be held confidential unless you agree to release it.

(5) I do [16%] do not [84%] wish the information I give to be released to my company. N=32

(6) What is your job title?

(7) Your highest degree? BA/BS-39% MA/MS-26% Ph.D. - 35% N = 50

(8-9) year?

	N
53-55 =	3
56-60 =	6
61-65 =	4
66-70 =	10
71-75 =	6
76-77 =	4

What % of your time is spent in:

avg. [34] managerial duties (10-11)
[61] technical duties (12-13)
[5] sales/marketing (14-15)

Do you work primarily in:

N=59 [73%] R & D (16)
[8] Production (17)
[12] Planning and Decision-making (18)
[7%] Sales/Marketing (19)
[0] Other (specify) (20)

How long have you been in Lithography?

0 = 10 1 yr = 7 2-5 = 17 6-10 = 8 11-15 = 5 16-20 = 1 (21-22)

	What were your goals in taking this course? # responses	How well were they achieved? Not at all	somewhat	very well
(23)	[46] updating technical information	[2%]	[41%]	[56%]
(24)	[33] knowledge of fundamentals	[-]	[64]	[36]
(25)	[29] perspective for decision-making	[10]	[45]	[45]
(26)	[23] meet others in the field and find out what they're doing	[10]	[71]	[29]

(27) How well did the pace of the course suit you?

[6%] too slow [94] about right [-] too fast

N= 51

	Did you find anything in the course that you could use immediately? If so, what? N		Did you find anything in the course that will affect your work in the long term? N	
E-Beam Fundamentals	22	(28)	24	(29)
Direct Exposure Systems	12	(30)	18	(31)
Resist & Processing	19	(32)	19	(33)
Nanometer Fabrication	4	(34)	14	(35)

(On the reverse side, briefly describe the ideas and techniques you found most valuable and how you have used them.)

Evaluation of the Electron-Beam Lithography Course,

How would you rate the instructors' emphasis on the following?

		too much (1)	about right (3)	too little (2)
fundamentals (36)	N = 51	[10%]	[78%]	[12%]
application (37)	N = 51	[-]	[73]	[27]
theory (38)	N = 49	[2]	[80]	[18]
current research (39)	N = 43	[7]	[84]	[9]

(40) How did this course compare with other engineering short courses you have taken? (in usefulness, content, interest)

N=51
[4%] the best I have taken (4)
[31] better than others I have taken (3)
[33] about the same as others (2)
[10] less satisfactory than others (1)
[22] have taken no others (0)

(41) Who initiated your decision to attend this course?

[85%] you [6] your supervisor [9] selected by company

N = 46

(42) How does your company support/recognize attendance at courses like this one?

N=59
[17%] company strongly encourages attendance (4)
[67] company pays fees and expenses (3)
[16] company grants released time (time off) (2)
[-] course attendance increases possibility of promotion/raises (1)
[-] no particular encouragement (0)

(43) Have you sought further instruction or done further individual or company research on the topics in this course?

[26%] major company research area (3)
[41] have done considerable research on my own time (2)
[10] have taken additional courses (1)
[23] no (0)

(44-45) Have you discussed the information gained in this course with your company colleagues? [62%] supervisor? [43]

(46) How useful have the lecture notes and/or other courses materials been to you?
[6%] very valuable [80%] quite useful [14%] not useful

(47) Do you think that taking this course has helped you professionally?
[76%] yes [13] no [11] am not sure

N = 53

Evaluation of the Electron-Beam Lithography Course, [illegible]

(48) If yes, explain.

(49) How much did your company benefit from sending you to this course?
[19%] a great deal [70%] somewhat [11%] not at all

N = 53

Explain:

(50) Would you recommend this course to a colleague? [94%] yes [6%] no
N=52

(51) What one suggestion do you have for improving this course?

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

N

[10] prefer telephone interview
[5] want further information
[21] do not wish to participate

[25] I'd like a summary of the final report

Please return questionnaire to:
Engr. Extension #XT37
U.C.B., 2223 Fulton, Berkeley, CA 94720

Answers to What is your job title?

Staff

6 Technical staff
Engineering science specialist
5 Engineer
Consulting member, engineering staff
2 Project engineer
Design engineer
Process engineer
Chief engineer
Senior engineer
Senior staff scientist
Associate engineer
2 Research associate
Group leader

Managers

2 Manager
Project manager
Section head
Photomask manager
Technical liaison
3 Laboratory manager
3 Engineering section manager
Systems operations
Operations
Physical science

Director

Research
Marketing
V.P., Engineering
V.P., Marketing director
President

Professor

Q. 27 Valuable Ideas and Techniques

23) As this was my introduction to the field, the immediate result was to acquire the technical language and concepts for communication with others in the field. As far as long term, only, or so much, as a broader background always influences.

24) Learned some techniques of value in designing electon-optical systems, especially from Hans Pfeiffer.

38) Ideas on columns and processing that I was able to bring back to my group and pass on to them for their follow-up.

41) Purchase of e-beam system.

49) Most valuable thing for me was the talk by Dr. Pfeiffer describing his IBM direct writing machine. The talk was very detailed, revealing most of its "secrets." I work for a company manufacturing e-beam lithography eequipment. The practical details are useful for me.

Q. 48. How Did the Course Help You Professionally?

I'm new to semiconductor industry. This provided good background.

Useful in managing new project.

Gives me insight as to direction towards which researchers in other companies are applying their money and time.

Now know capabilities of e-beam lithography.

It was a good in-depth introduction to e-beam lithography.

Better perspective on e-beam systems and techniques.

General knowledge, trends.

It has provided a good background of material related to future decisions.

It has given me general background concerning e-beam processing.

We will be forced to make a decision w.r.t. e-beam lithography. I think we're better prepared.

Useful for my decision making, as a general e-beam technical information and knowledge for me.

My job is to develop the competing/complementary technology of x-ray lithography so I must have a good understanding of e-beam lithography concepts and procedures.

The main value was in discussing the material covered with the instructors (after hours).

I now know what IBM has done--at least, the order of magnitude. I also know how poorly the market was analyzed in 1975 and how tightly IBM can hold secrets.

Gained better overall impression of state of the art in e-beam lithography--what's commercially available and its limitations compared with IBM/BELL/TI systems.

Currently making decisions related to e-beam technology within the company.

There will come a time when I will be using e-beam equipment. Courses like this will make NBK more effective when the time comes to purchase equipment.

Knowledge of the state of lithographic art helps me evaluate plans for our research activities.

Had little general knowledge of lithography at the time I took the course.

Awareness of customers' fabrication techniques and general knowledge.

IC design and fabrication is the most important future activity for engineers in our company.

Personal contact and stimulation of ideas.

Maintain technical understanding.

I gained a much better understanding where the state of the art is--which as an industry watcher is very important.

Q. 48. How Did the Course Help You Professionally? (Cont'd)

Provided background.

Update of information is clearly useful.

Professional contacts, useful information.

Wider scope of knowledge in this area.

Industry contacts were helpful.

In my company we do not have any immediate plans to get involved in exotic technologies like e-beam. We do however need to keep abreast of the major developments in the field. I found the course to be useful for this purpose as I have found others of the Berkeley courses that I have attended.

Information obtained has added to my ability to make appropriate decisions regarding this subject.

Q. 49. How Much Did Your Company Benefit?

I don't know.

?

Not At All:

Course benefits were primarily to myself.

No immediate work-related relevance.

A Great Deal:

It was very beneficial for planning the future.

My field is advanced lithography now even though I had little previous background in this area.

Gained initiation into vocabulary and many aspects of literature, current work, approaches to e-beam technology which will serve in good stead as basis in further, more detailed research.

(Cont'd)

Q. 49. How Much Did Your Company Benefit? (Cont'd)

(A Great Deal):

If I don't know this, I can't do my job.

When we make a decision on advanced lithography, it will be from an informed position.

Somewhat:

The company benefits whenever I am able to expand my knowledge and/or meet others in the field. In this case, I established contact with 2 people who are new customers, and picked up background data on secondary electron generation which eventually lead to a major decision in e-beam area.

Nothing new was discussed. Some contacts with people at the meeting were useful.

Useful information is beneficial. (Lower costs), shorter development time.

Helped in selecting a system for purchase.

Making me aware of problems and developments in other areas.

Added background information to R & D work in progress.

We are just getting into integrated circuit design, and it is useful to us to know alternatives.

Obtaining list of attendees. Contact with interested parties who could become customers in the future.

Most of lectures are reviews, but somewhat in current and practical technology.

This will be more evident when we begin to follow through on plans to set up an e-beam facility.

This isn't a company. My research program benefitted.

Very difficult to evaluate.

Again w.r.t. deciding about pursuing e-beam lithography.

Lithography is not my area of responsibility, so there is slight direct benefit. But my understanding of problems and opportunities raised by e-beam is an enhancement.

Benefits still in future.

General knowledge.

Increased my knowledge of potentially applicable techniques. Has not yet been implemented.

I couldn't absorb it all. Much of significance is beyond me.

Q. 50. What one suggestion do you have for improving this course?

3) Everhart should have printed material of his opening remarks!

6) Follow it up with lectures from different companies, and make it an ongoing, upgraded series, rather than a single session.

Q. 50. What one suggestion do you have for improving this course? (Cont'd)

11) I would have preferred more detail on e-beam systems. This, however, is the viewpoint of a person who works with an e-beam system.

14) I thought it was about right. Perhaps more time at the end of the day to talk informally would have been good.

15) Having a preliminary summary of fundamentals sent to participants before the class.

17) Greater depth in less area. Treatment was too broad with the exception of resist mechanism and dosage.

18) Better notes. A well notated list of references.

19) Too short--need to be more thorough.

20) More on real-world applications of this technology.

22) Avoid repeating last year's material.

23) Lecture notes could delve in to all areas more thoroughly than lectures themselves, rather than merely repeating.

24) Greater depth of coverage of current research and applications.

25) Don't let a single company dominate the program.

26) Start with the assumption that 50% of the audience knows nothing at all about e-beam. Build up slowly to the more complex material--two days might be better.

27) Provide more detail.

30) Would like to have more accurate information on the quality and quantity of masks presently being manufactured on e-beam equipment. Not just isolated, but in a production operation.

32) It is difficult because the audience background is so diverse. I think that you did about as good a job as possible.

34) Mail notes to participants ahead of time.

38) Break it into levels for the beginner and the experienced researcher.

40) Better handouts at the course.

41) More practical application details.

42) Please completely separate fundamentals and tutorials from current technology. Like the former in the morning and the latter in the afternoon.

43) More discussion time--better organized.

46) Less IBM dreams.

SUMMARY OF THE EVALUATION OF AIRPORT SYSTEMS & DESIGN CEE COURSES U.C. Berkeley, Engineering Extension (1978 and 1979 classes)

Evaluators: Martha Maxwell, Ph.D.,
Project Director
Caroline Showers, M.S., R.A.

The Airport Systems Planning and Design Short Course has three goals: 1) to provide a general introduction to airport planning; 2) to give an annual update on new information in the field; and 3) to discuss new regulations for airport systems and the outlook for government funding. The four-day class is divided into four topics: planning and economics, operations, design, and environmental planning.

This evaluation is based on the results of questionnaires administered during the last days of the 1979 class to 32 participants, follow-up questionnaires returned by 21 of those attending the 1978 class, and interviews with the faculty coordinator and four participants.

Characteristics of Participants

The Airport short-courses attract students from a wide range of airport-related jobs--planners, engineers, government officials, managers, architects, and other specialists. The average participant completed a college degree within the past ten years and has worked in airport-related jobs for about three and a half years. Twenty-five percent of the 1979 class had less than one year's experience in airports. However, in both classes there were some people with over 20 year's experience. Most participants have administrative responsibilities and take the course to improve their general background and update their knowledge. Students in both classes report that the course met these goals well. Those who came for other goals (decision-making, meeting others, learning fundamentals) were somewhat less satisfied. Most participants felt that taking the course was valuable to them professionally, increased their knowledge, and gave them fresh insights. Those who had taken other courses rated the course as somewhat better than other short courses they have taken. The average participant was satisfied with the course.

On the average, participants felt that the course level, and length was about right, although about a quarter felt the course was too fast, too short, and the content too easy. Participants rated the instructors as average to good, but judged the discussion and problem-solving sessions as weaker than other parts of the course. (Some questioned whether there were any problem-solving sessions.) Also a number complained that there was not enough emphasis on applications. Note- some people attending the course had rather specialized interests such as expanding very small airports or building airports in the bush. It is difficult to address this range of interests in a lecture. Others wanted site-visits and more emphasis on case-studies, and some were disappointed that there was not more state-of-the art information.

This study was supported by the National Science Foundation under Grant #SED-78-22138. The opinions, findings, conclusions, and recommendations expressed are those of the author, not of the National Science Foundation.

In both classes, some participants complained that there was not enough participant involvement in discussion or panels. Increasing the opportunities for participants to talk with one another and with the speakers is one way to meet the students' varied needs. Also some complained about the length or the lectures and the length of the day while others in each class requested a longer course. (i.e., a 5-day course rather than 4 days.)

Recommendations

1. Encourage those with special interests to form groups or meet others with similar interests individually (i.e., those from small airports, or those interested in design.) The course could be planned with an opening social hour. More time could be scheduled for breaks (30 minutes vs. 15 minutes.) Opportunities could be given at the opening session for students to indicate their interests and find others with similar interests and problems.

2. Plan the course to include more discussion groups (course topics, case studies, and problem solving) even if some of the formal presentations must be shortened. Consider reviving the panel discussion sessions, and schedule these during the early afternoon or morning if there's a problem with people leaving early in the late afternoon.

3. As is typical of students in other CEE short-courses, participants in the airport courses show an increased interest in taking other short courses on the topics covered by the course. Some of this interest may stem from the course coordinator's deliberate trade-off between presenting general information on a number of topics vs in depth coverage of a few topics. U.C. Extension should consider extending this course or offering other airport short courses that would provide opportunities for participants to cover the topics in more depth. The topics that seem to be of most interest include financial management and planning, architectural design and construction, transit planning/multimodel planning, and environmental planning (essentially the main topics covered in this course).

Another way to provide interested participants who want more detail on some of the topics, would be to schedule some double sessions during the 4-day course where students would have to choose between two topics.

4. There were a few comments that suggest some participants expected more emphasis on design. This seems to stem from the course title which, they felt, implied a 50-50 split between design and systems. Although the course description clearly explains the emphasis and time devoted to each topic, the coordinator might consider how the title might be changed to avoid this problem.

EVALUATION OF THE AIRPORT SYSTEMS PLANNING AND DESIGN SHORT COURSES
U. C. Berkeley Engineering Extension
(June 1978 and June 1979)

Evaluators: Martha Maxwell, Ph.D.
Caroline Showers, M.S.

Summary of Interview with Professor Kanafani, Faculty Coordinator, the Airport Systems course has three goals: 1) to provide a general introduction to airport planning; 2) to give an annual update, presenting what is new in the field; and 3) to discuss new regulations for airport systems and the outlook for government funding. One day of lectures is devoted to each of four major topics--Airport Planning and Economics, Operations, Airport Design, and Environmental Planning.

The course is designed for professionals in a variety of occupations relating to air transportation. The group will include engineers, planners, architects, economists, and government officials. These people may be employed by airlines, airports, consulting firms, universities, and by the local or federal government. Some may also come from overseas. The course is intended for professionals practicing in another sector of air transportation who want to broaden their knowledge to include airport systems and hence the emphasis is on introductory concepts. The annual update and discussions of regulations and funding may appeal to people with more direct experience of airport systems. It is expected that all participants will be college graduates who have majored in a technical field or economics and are now professionals in a field related to airport systems.

The faculty coordinator anticipated that most participants from the public sector would probably work in local governments, as the federal government has its own training courses of this type. The involvement of government officials in airport systems is usually from a client's perspective--they have design or operations work done for them by a private organization. They may also play a supervisory role, which entails approval of airport plans or formulation of airport regulations.

The course has been given eight times. Over the years, the course format has been similar, however, each year two or three topics are changed to include current information. The few people who repeat the course do so after a four- or five-year interval. Usually, a company sends one or two of its employees each year, usually new employees.

One benefit of the course to students is that they learn to design airports (e.g., runways, hangars, etc.) or to add new facets to their previous design perspectives. Design methods are published in the course materials which are very complete and include lecture texts, supporting reference articles, instructions for design, and sample problems. The company benefits by obtaining these materials and also by the business contacts that are made.

The instructional method is informal lecture with a number of visual aids. One or two lectures resemble workshops in that they demonstrate problem-solving. Questions are permitted at any time. In the past, the coordinator has tried to end each day with a panel discussion, but he feels that this is not worthwhile because most participants prefer to leave earlier and explore the Bay Area. The only problem the instructor anticipates that students might have involves the breadth vs. depth trade-off. A wide range of material is presented, and, from the individual's point of view, some topics will be belabored and others will be passed over too quickly.

The lecturers change every year and are selected personally by the coordinator because of their expertise on certain topics. Most come from local consulting firms and many are former Berkeley students. Topics are selected in terms of important factors of airport systems and current relevance (e.g. environmental planning).

As mentioned above, the faculty coordinator stated that course notes are extensive and well-prepared, and are distributed at the course. No preparatory reading is suggested.

Summary of Replies by 1978 Class

Twenty-one questionnaires of the forty-eight sent were returned. The responses seem to be affected by the year's lag between course and evaluation. There were fewer written comments responses and there was a tendency to give average ratings.

Sixty-eight percent of the group have Bachelor's degree, one is a Ph.D. candidate and the rest have Masters' degrees. They earned degrees over a 35 year span with 27% having graduated in the past 4 years. Job duties show an even split between managerial and technical, typical of airport systems work. Sixty-eight percent of the group are either engineers or planners; there is one architect, 4 government officials, no economists, and one person who described himself as a contract negotiator.

Fifty-eight percent have worked with airport systems for 5 years or less. The goals of improving background and updating knowledge were rated as most important while fundamentals, perspectives, and meeting others were considered less important (rating 3). The achievement of goals shows a large variance, so that one cannot generalize from average ratings. Achievement is roughly satisfactory.

Seven persons expected to learn something that wasn't covered in the course and 3 had taken related courses. The course was rated better than others they had taken. Emphasis on research, fundamentals, applications, and theory was rated about right by most people. Significant deviations are that 26% said there was too little emphasis on research and applications.

The various topics in the course were rated, on the average, between 2 and 3 on a 1 to 4 scale of usefulness. A large variance blurs any distinction among topics.

Twelve persons commented on valuable ideas and 12 persons found the notes useful. Nineteen persons said the course helped them professionally to some degree and 14 persons suggested ways to improve the courses; 8 persons suggested other course topics.

The question concerning what topics in the course could be used immediately or in the future did not elicit many responses. Operations, Airport Design, and Environmental Planning were said to be useful immediately, while airport planning and economics were judged as useful in the future. Only 56% of the people returning questionnaires answered this question.

The average grades for instructors ranged from B+ to C+. Grades assigned individual instructors showed a large spread. Various aspects of the course were given the following average grades: Discussions, C; Social and economic factors, B-- or C++; Fundamentals, B; and Applications, C+.

Twelve people rated the course better than others they had taken, 8 about the same, and 4 less satisfactory than others. All but 2 participants intend to do further study on the course topics as part of their jobs and 10 plan to study them on their own time.

Eight-four percent anticipate discussing information learned in the program with their colleagues; and their supervisors. Seven persons expect to use the course notes regularly, 14 think they might use them, and 1 does not expect to use them. All but two said that they'd recommend the course to a colleague.

Three people wrote what they thought was most valuable and 69% thought the course helped them professionally. Twenty people made suggestions for improving the course and 11 gave ideas for other courses. Six made further remarks.

[See Questionnaire following]

[ ] [ ] [ ] [ ]

AIRPORT SYSTEMS PLANNING & DESIGN 1978

Follow-up Questionnaire

(N=21)

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its short courses for engineers. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

5. What is your job title?

6-8. Your highest academic degree?
BA/BS-8 MA/MS-6 PhD-1

year received?
56-60-6
61-65-2
66-70-3
71-75-4
76-79-2

9-10. What % of your time is spent in:
Mean = [47%] managerial duties

[50%] technical duties

[3%] other (what?)

11. Do you work primarily as an:
40% [8] engineer
30 [6] planner
5 [1] architect
20 [4] government official
[0] economist
5 [1] other (specify) Contractor/negotiator

12-13. For how many years has your work been related to airport systems?

	1	2-5	6-10	11-20	21-30
N=	1	11	3	4	1

14-18. What were your goals in taking this course? Rank order.
1 = most important
4 = least important

$\bar{X}$	# ranking it most important
3.0	[3] learning the fundamentals
2.1	[7] improving general background
2.0	[3] updating knowledge
2.8	[3] acquiring a perspective for decision-making
2.9	[1] meeting others in the field and finding out what they're doing
	[ ] other (what?)

AIRPORT SYSTEMS PLANNING & DESIGN 1978

Follow-up Questionnaire
(N=21)

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its short courses for engineers. Your respones to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answere these questions.

5. What is your job title?

6-8. Your highest academic degree?
B/A-14 MA/Ms-6 P.h.D-1

year received?
56 - 60-6
61 - 65-3
66 - 70-3
71 - 75-4
76 - 79-2

9-10. What % of your time is spent in:

Mean = (47%) Managerial duties

(50%) Technical duties

(3%) Other (what?)

11. Do you work primarily as an:

%		
40	(8)	Engineer
30	(6)	Planner
5	(1)	Architect
20	(4)	Government official
	(0)	Economist
5	(1)	Other (specify) contractor/negotiator

12-13. For how many years has your work been related to airport systems?

	1	2-5	6-10	11-20	21-30
N=	1	11	3	4	1

14-18. What were your goals in taking this course? Rank order
1=most important
4=least important

X	#ranking it most important	
3.0	(3)	learning the fundamentals
2.1	(7)	improving general background
2.0	(3)	updating knowledge
2.8	(3)	acquiring a perspective for decision-making
2.9	(1)	meeting others in the field and finding out what they're doing
	( )	other (what?)

19-24. How well were your goals achieved?

	not at all	some-what	satis factorily	very well
learning fundamentals	( )	(24%)	(62%)	(14%)
updating knowledge	( )	(10%)	(55%)	(35%)
perspective for decision-making	( )	(33%)	(56%)	(11%)
meeting others	(10%)	(32%)	(53%)	(5%)

25. Was there something you expected to get from this course, but did'nt?

7 or 33% yes, If so, what?

26. Have you taken other courses on these topics in the past 2 years?
yes=3 If so, what?

Same type of course at Ga. Tech.
Refresher planning, FAA Academy
Same type of course at MIT
(MIT course better because it had a more diverse, interesting group of speakers.

27. How did this c-urse compare with other engineering short courses you have taken? (in usefulness, content, interest)

%	
(5%)	the best I have taken
(43%)	better than others I have taken
(19%)	about the sames as others
(5%)	less satisfactory than others
(28%)	have taken no others

28. How would you rate the instructors' emphasis on the following?

	too much	about right	too little
current research information	(0)	(71%)	(29%)
fundamentals	(10%)	(90%)	(0%)
application	(5%)	(66%)	(29%)
theory	(5%)	(86%)	(9%)

29-33. How useful have you found the topics covered? Rank Order

1=most useful
4=least important

X	
(2.1)	airport planning and ecomonics
(2.5)	airport operations
(2.3)	airport design
(2.8)	environmental planning

34. What ideas and techniques have you found most valuable?

SEE LIST

35. Have the notes/course materials been useful in your work?

Yes 68% No or haven't used 32%

36. Do you feel that this course has helped you professionally?
If so, what? 19 said yes, 1 said no.

37. What suggestions do you have for improving this course?
14 people made suggestions

38. What other short-courses would you like to take?
8 people made suggestions

Other remarks?

Summary of Responses of 1979 Class

Forty-six persons registered for this four-day course and 32 completed questionnaires at the end of the course.

Characteristics of Participants

With one exception, the respondents were college graduates, including 9 Master's and 1 Ph.D. Sixty-three percent had received their degrees in the last ten years, making this a relatively young group. The average respondent spends 40% of his time in managerial duties and 51% in technical affairs. Ten people mentioned other activities such as teaching, public duties, and field assignments. The participants included 14 planners, 13 engineers, 5 government officials, 2 architects, no economists and 5 "Others" (2 teachers, 1 field maintenance, 1 safety, 1 airport operations). Twenty-five percent had less than one year's experience in arport systems, and 72% had less than five years' experience.

Participant Evaluations

Participants ranked their goals for this course as follows, from most to least important: 1) improving general background; 2) updating knowledge; 3) learning fundamentals of a field new to me; 4) acquiring a perspective for decision-making; 5) meeting others in the field. One person mentioned business contacts and ranked this goal third. It appears that most participants do not consider themselves "new to the field," but are interested in improving their backgrounds. The first three goals were found to have been met satisfactorily, and the latter 2 were judged as being "somewhat" satisfied.

Twenty-five percent said that there was something they expected to learn in the course but didn't. Most people found the pace, length, and level of the course to be about right. However, 19% said the pace was too fast, 28% said the length was too short, and 25% said the level was too easy.

(For details, see Questionnaire following)

AIRPORT SYSTEMS PLANNING & DESIGN - June 18-21
June 1979 Class
Questionnaire
N=32 replies our of approx. 46 registrants

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its short courses for engineers. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

5. What is your job title? (See p.4.)

6-8. Your highest academic degree?
Less than BS=1 BA/BS=20 MA/MS=9 P.h.D.=1

Year received?
50 - 55=1
56 - 60=-
61 - 65=4
66 - 70=4
71 - 75=12
76 - 79=8

9-10. What % of your time is spent in:

Avg= (40%) managerial duties
(51%) technical duties
(9%) other (what?)

11. Do you work primarily as a

(36%) planner
(33%) engineer
(0%) economist
(5%) architect
(13%) government official
(13%) other (specify)
2 teachers field maintenance safety
Airport operations

12-13. For how many years has your work been related to airport systems?

1	2-5	6-10	11-20	21-30	31-40
8	15	4	2	2	1

14-19. What were your goals in taking this course? Rank order the following using #1 for the most important; #6 for least.

Avg.	# listing each as most important
3.0	(8) learning the fundamentals of a field new to me
1.5	(15) improving general background
2.1	(9) updating knowledge
3.7	(1) acquiring a perspective for decision-making
3.8	(1) meeting others in the field and finding out what they're doing

( ) other (specify) contacts=167

20-26. How well did the course meet your goals?

	not at all	somewhat	satisfactorily	very well
	%	%	%	%
learning the fundamentals	(3%)	(30%)	(50%)	(17%)
improving background	(3%)	(10%)	(57%)	(30%)
updating knowledge	(6%)	(19%)	(52%)	(23%)
acquiring a perspective for decision making	(13%)	(60%)	(37%)	(13%)
other?	( )	( )	( )	( )

27. Was there something that you expected to learn in the course, but did'nt? if so, what? 8 persons said "yes" (25% of group)

28-30. How would you rate the course on the following?

	%		%		%	
pace	(19)	too fast	(24)	about right	(7)	too slow
length	(7)	too long	(64)	about right	(29)	too short
level	(26)	too easy	(71)	about right	(3)	too hard

	Did you find anything in the course that you could use immediately? If so what?	Did you find anything in the course you can use in the future? If so, what?
	#	#
Airport planning &economics	4	7
Operations	7	3
Airport Design	8	5
Environmental Planning	10	4

(On the reverse side, briefly describe the ideas and techniques you found most valuable and how you plan to use them.) 3 persons commented

How would you grade the instructors on content and presentation. Use A=Excellent; F=Very Poor

	Avg. Grade			
Antis	(C+)	Brawner	(B-)	Paul (A-)
Doyle	(B+)	Galloway	(B-)	
Gosling	(B)	Hockaday	(B+)	
Howard	(B)	Kanafani	(B)	
Joerger	(B-)	Pollack	(C+)	
Robert	(B-)	Ashford	(B)	
Wesler	(B+)	Whitehead	(B-)	

45. Rate the following aspects of the course using A=Excellent through F=Poor.

Averages (C) discussion and problem solving workshops
(B-) social and economic factors

Averages

(B) fundamentals (theory and research)
(C+) applications

46, How did this course compare with other engineering short courses you have taken? (in usefulness, content, interest)

%	
(0)	the best I have taken
(18)	Better than others I have taken
(25)	about the same as others
(12)	less satisfactory than others
(25)	have taken no others

N+32

47. Do you plan to do futher study on the topics in this course?
(17%) yes, as part of job
(23%) yes, on my own time
(0%) doubt that I'll do more study
(0%) am sure I won't

48. Do you plan to discuss the information gained in this course with your company colleagues? (73%) supervisor? (73%)

49. Will the course materials be useful to you in your work?

(31%) expect to use them regularly
(64%) may use them
(5%) doubt that I'll use them N=22

50. Do you think that taking this course will help your professionally? If so, how? Yes=22 or 69%

51. Would you recommend this course to a colleague? (7%) No (93%) yes N=30

52. How might this course be improved? 20 people made suggestions

53. I would like to participate in a short course on: 11 ideas

Other remarks? 6 comments

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

( ) prefer telephone interview
( ) want further information
( ) do not wish to participate

AIRPORT

Participants' Suggestions for Improving the Course

Content

More talks of how to improve an existing airport and facilities and not how to build a new one. There are very few new airports in the world.

Too much emphasis on planning; split planning and design more equally. (2)

Extend course to cover more design considerations, or separate it into two different courses, one for planning, one for design.

More practical planning approaches from the airlines' point of view.

More discussion on problems of smaller, growing airports--not just relating examples to major world airports.

More emphasis on multimodal--and an airports system planning, i.e., a system of airports.

Cargo lecture is too specific--should be restructured to focus on how cargo fits into the entire system--financially, operationally, etc.

Speakers

It would be difficult, but all instructors should review each other's notes so that repetition and overlap can be avoided.

Have speakers add index for abbreviations in their notes to eliminate student confusion.

Six topics were presented by consultants. Five of the six were by P.M.M. This gives the appearance that they have the only experts available and places other consultants at a disadvantage.

Try to provide equal representation from consultants who give presentations. P.M.M. was overly involved in program.

Improve quality of presentations.

Have more professionals for presentations and fewer academicians should be involved, as they are out of touch with the realities of the business.

Most speakers were incredibly boring. Perhaps a different format should be tried. Panels were better than individual speakers.

Speakers (cont'd)

Broaden the range of speakers--seemed like too inbred a group. Increase participation by practitioners (the airline executive who participated in fleet planning was good.) Gosling's stuff was much too basic. Kanafani needs to add life to presentations. Environmental presentations were useless.

Speakers should refrain from speaking on the subject matter only as it relates to their airport.

Your expert speakers were obviously well-qualified in their fields, but they were apparently not too excited about participating. Please don't teach FAA manuals.

Put more emphasis on new techniques, ideas, etc.

Eliminate complicated subjects unless time is allowed to properly address the subject.

Discussion/Problem-Solving

Participants can learn much from each other. Encourage contacts.

Increase the discussion sessions (3)

Would like to see additional problem solving sessions. (2)

More case studies. (4)

Develop problem-solving atmosphere.

Discussion on the effects of deregulation.

Organization/Scheduling

Organization of seminar overall was good.

Lengthen course to 5 days with longer lunch. Find a decent hotel (other than Hotel Durant). Provide more information on San Francisco (eating, entertainment). Schedule more social gatherings--luncheon or dinner with guest speaker or informal activities.

Daily lecture schedule rather long.

Extend course to full week. (3)

5 to 8-hour days too short. Evening sessions would be appropriate to hold it to a week.

Organization/Scheduling (cont'd)

Fewer topics/greater detail.

Increase the amount of topics, the amount of subjects in each topic and discussion sections.

Limit lectures to one hour between breaks. Need classroom work with field trips appropriate to the course and location. Bay Area has much to offer those of us in less sophisticated environments in terms of facility experience.

Course Materials

Complete list of bibliographical materials in these fields; brochures, pamphlets, pictures--All should have been given out as a package.

Include some case studies on handout.

Responses to Q. Describe the ideas and techniques you found most valuable

1979 Class

Because each topic was necessarily general in nature, I believe the most important aspect was in providing references to both design and planning texts, but also to individuals and companies in the field.

I got the impression I'm on the right way toward doing my job!

Terminal cargo--good "rule of thumb" technique useful in landside planning.

Economic planning--provided good background on the economic operation of a larger airport. Will help one provide advice to clients.

1978 Class

Design and operational techniques.

Those relative to facility planning (as opposed to land use and runway planning).

All have assisted in refreshing my knowledge of various aspects of planning.

General background

Design for flexibility.

1978 Class (cont'd)

Airline planners' discussions of operational needs and planning criteria.

Airport management in face of deregulation; environmental impact statements.

Airport planning and projection of needs.

Perspectives of Washington-level environmental people and air cargo managers were helpful.

Design of apron and terminal facilities.

Forecasting the demand for air transportation. Also, environmental and noise sections.

Recognition of various perspectives of noise problem.

The idea that there are several points of view on any problem.

How Course Helped Them Professionally

The most frequent answer was "By broadening my background." Some other examples:

The major benefit of this course is to become more knowledgeable in some areas so as to aid in professional interactions with individuals in those fields.

Currently involved with many issues covered in the course.

In gaining a more general knowledge of airport planning and operations.

Update information; identify sources of additional information--notes and references.

Introduction to new work area.

In planning and administration, coordination and problem studies.

Gave me insights into planning and design needs of airlines.

To keep up with rapidly changing field of noise evaluation.

Fundamental technical knowledge.

It brought me up to date and refreshed my knowledge of the industry.

Perspective and personal contacts.

Gave me good concise information that I can use everyday.

What They Expected To Learn, But Didn't

1979 Class

Less theory--more practice

Course has too much "what" and not enough "how"

Specific detailing on design

Much of course was a review type approach. I needed more fundamental material.

I expected more precise definitions, examples of some aspects of this course.

Alternative airfield design concepts.

Site location decisions.

If there was a national scheme for developing airports. It seems this is a hodge-podge industry.

Would have enjoyed a little more direction toward general aviation activities and operations.

1978 Class

More emphasis on multi-modal transportation planning.

New ideas or techniques.

A little more 'hands-on' analysis exercise in, e.g., capacity or gate occupancy.

More specific case study situations.

More student input.

Planning

More state-of-the-art information--i.e., forecasting advances.

Responses to Q. 53. "I would like to participate in a short course on..."
(1978 & 1979 groups)

Financial management, planning; airport economics with emphasis on cost-effective approach to design, construction, and operations. (5)

Airport architectural design and constructions; actual design applications; aviation facilities (2) (as related to bush and developing countries (1) (Total - 5)

Airport environmental planning, growth and management in land use planning (3)

Transit planning: engineering education/urban transportation planning and policy analysis; multimodal system planning (3)

General aviation (3)

Airline and airport management and marketing (2)

Those that might examine individual items like runway capacity in greater detail (2)

Forecasting (1)

Lease agreements on airports; financing alternatives, airspace capacity and analysis (1)

EVALUATION OF THE EXPONENTIAL SMOOTHING AND ADAPTIVE FORECASTING TECHNIQUES COURSE OF JUNE 27, 1979. U.C. Berkeley, Continuing Education in Engineering. (Prof. Robert M. Oliver, Faculty Member in Charge.)

Evaluators: Martha Maxwell, Ph.D.
Carolin Showers, M.S.

Nineteen of the 26 students enrolled in the Exponential Smoothing and Adaptive Forecasting CEE Course (June 27, 1979) returned follow-up questionnaires. Although the 53 percent of the class who responded may not be representative of the total class, their responses suggest that the class was widely diverse in regard to preparation, experience, and expectations for the course. Considering the heterogeneity of the group, it is not surprising that student evaluations of the course were mixed. (See Appendix attached for response distributions.)

Six students (32% of the class) said they had taken no other courses in forecasting while 13 had. However, some of the latter group wanted and (apparently) needed an intensive review of basic fundamentals so that even if admission to the class were made contingent on students' completing basic courses in forecasting, the class would still contain people with diverse needs and there would be a good chance that it would not attract enough students.

What this diverse group did have in common was an interest in the subject and the motivation to learn more about the field.

Teaching short courses to such a varied group of students poses many problems for the instructor-in-charge. The following are some teaching strategies used by other instructors in organizing and planning such information-intensive, one-day engineering short-courses where students vary widely in background and experience:

--Alert students in advance of the course to some basic materials to review in preparation for the course. These might include a textbook or summary articles. The easiest way to do this is to include references in the course brochure (or students could be sent a list before the course.) Not all of the students will read materials in advance but references can be very helpful to some students. Others won't review the materials before coming to the class, but may be inspired to read them afterwards.

-- Plan a brief (about 1 hr.), thorough introductory lecture covering the basic concepts in the field and open the class with this. Explain that this information will serve as a review for the more advanced students, but will help the others get a foundation for the rest of the course. (Advanced students are usually tolerant and accept this kind of explanation.)

-- It is essential that students be given a rather complete outline of this introductory lecture that includes the topics, key terms and their definitions, formulae, main concepts, and some references. Underprepared students are less critical of courses where they are given notes that they can review afterwards, and , in this course, the majority indicated that they planned to do further study on the course topics.

Increasingly, engineers who attend CEE courses expect good, well-organized, course notes to be distributed by

instructors and notes make it easier for the instructor to cover the course objectives in a limited time.

--Introduce each course topic by presenting carefully selected examples or problems, discussing these, and then presenting the underlying theory. Discussing examples first reduces the frustration of the less sophisticated students while maintaining the interest of the more advance, ones. Students respond well to what they consider real-life examples or problems .

--If possible, organize course around projects (i.e., have students send in descriptions of their projects or collect examples from students who have taken the course before.)

--Set limits on the number and kinds of questions students may ask. Some instructors answer only questions involving clarification during their presentation, deferring discussion questions until the end of the session (or end of the day.) If students are allowed to debate speculative issues it can take a lot of class time and alienate the rest of the class who feel left out. (Some Berkeley students are experts in diverting the instructor's attention from the course topic by their questions.)

-- Allow enough time during coffee breaks for students to talk with each other and those who have questions to talk to the instructor. (Note: 15 minute breaks are often too short-- 20 minutes are better, if they can be arranged.)

-- CEE classes often vary in composition from one time to another. If a few questions are included on the course brochure for students to fill out and send in with their registration fees, the instructor can get some ad vance information about the kinds of people who'll be in the class. For example, questions on demographic characteristics, interests, and experience in using various forecasting techniques, types of porjects involved in..could be asked. This information would help the instructor in planning the course and also help the students recognize that the instructor is aware of their needs.

June 27, 1979

EXPONENTIAL SMOOTHING & ADAPTIVE FORECASTING
TECHNIQUES FOLLOW-UP QUESTIONNAIRE
(N=19 Questionnaires returned out of 36 sent)

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its engineering short courses. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

%. What is your job title? See page iv.

6-8. Your highest academic degree?
BA (2); BS (5); MBA (2); MS (6); P.h.D. (3) Year received?

9-10. What % of your time is spent in: AVERAGE

( ) managerial duties 20%
( ) technical duties 80%
( ) other (what?) (marketing mentioned by 2)

11. Do you work primarily as a

(7) corporate planner Other? (What?) 12

12-13. For how many years has your work involved forecasting?

0=2; 1=1; 1-2 yrs.=6; 3-5 yrs=5; 6-9=2; 10+=2

14-26. What were your goals in taking this course? Rank order the following using #1 for the most important; #6 for least.

	How well were your goals achieved? not at all	some what	very well	no. resp.
( ) Learning the fundamentals of a field new to me	(6) 31%	(11) 58%	(0)	(2) 11%
( ) improving problem solving ability	(4) 21%	(9) 47%	(1) 5%	(5) 26%
( ) updating knowledge	(1) 5%	(13) 67%	(3) 16%	(2) 11%
( ) acquiring a perspective for decision-making	(3) 16%	(10) 53%	(3) 16%	(3) 16%
( ) meeting others in the field and finding out what they're doint	(9) 47%	(4) 21%	(0)	(6) 32%
( ) improving general job skills	(3) 16%	(9) 47%	(2) 11%	(5) 26%
( ) other (specify)	( )	( )	( )	( )

27. Was there something that you expected to learn in the course, but didn't? If so, what?

See P.V.

28-30. Please rate the course on the following?

pace	(4) too fast	(8) about right	(7) too slow
length	(3) too long	(5) about right	(11) too short
level	(2) too easy	(9) about right	(8) too hard

31. Please describe the ideas and techniques you found most valuable and how you plan to use them.

See P. VI.

32. Rate the following aspects of the course using A=Excellent through F=Poor.

	A	B	C	D	F	No answer
( ) fundamentals	4	2	7	1	3	2
( ) theory	3	4	5	1	4	2
( ) applications	6	3	1	2	6	1
( ) Audio-visual systel	11	5	1	-	1	1
( ) use of computer terminal	10	4	-	2	-	3

33. Have you taken other courses in forecasting? Yes=13 No=6

34. How does this course compare with other engineering courses you have taken? (in usefulness, content, interest)

(0) the best I have taken
(3) better than others I have taken
(3) about the same as others
(5) less satisfactory than others
(8) have taken no others

35. Do you plan to do further study on the topics in this course?
(12) yes, as part of my job
(9) yes, on my own time
(3) doubt that I'll do more study
(0) am sure I won't

36. Have you discussed the information gained in this course with your company colleagues? (17) supervisor? (15)

37. Will the course materials be useful to you in your work?
(2) expect to use them regularly (13) may use them (3) doubt that I'll use them
(1) expect to use, but not regularly

38. How might this course be improved?

See P. VI

39. I would like to participate in a short course on:

See p. viii

Other remarks?

See p. viii

The NSF Evaluation Project Team is planning to conduct brief phone interviews with participants of this course to assess the usefulness and applicability of the information covered. If you are willing to take part in a brief interview, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

[ ] want further information
[ ] prefer telephone interview
[ ] prefer that you contact:

Name_____

Phone_____

Job title_____

[ ] do not wish to participate

Return to XT 37 Engr. Extension
2223 Fulton St.
Berkeley, CA 94720

Replies to Q. 5- What is your job title?

-- Sr. Programmer/Analyst

-- Financial Analyst

-- Systems Analyst

-- Sr. Assoc. Systems Analyst

-- Director of Analytical Services

-- Senior Operations Research Analyst

-- Marketing Analyst

-- Planning Analyst

-- Manager Manpower Planning

-- Sr. Market Planning Analyst

-- Assoc. Civil Engineer

-- Analyst/Programmer

-- Administrative Analyst

-- Forecasting and Planning Analyst

-- Manager of Planning

-- Assistant Dean

-- Mathematician/Programmer

-- Senior Associate (Consultant)

Responses to Question: Was there something you expected to learn in the course, but didn't? If so, what.

--reason for using exponential smoothing model vs other techniques.

--I thought the course would concentrate more on different formulations of adaptive forecasting.

--More practical discussion of forecasting techniques and use of the computer.

-- Specific model formulations.

-- A factual, non-theoretical approach to forecasting.

-- A practical and simplified method for doing forecasting via exponential smoothing.

-- Hands-on experience.

-- Exponential smoothing.

-- No.

-- How to actually apply the theory.

-- Expected to see a more balanced approach between academic and professional presentation perspective. Too much Greek/ Could have been done in a more verbal context much better.

Responses to Question: Please describe the ideas and techniques you found most valuable and how you plan to use them.

-- Smoothing & forecasting of low data rate (1 sec. ≥ sample ≥ 15 mins.) Instrumentation systems.

-- Have already used double exponential smoothing to arrive at a forecast based in extensive professional situations. Find it most useful over very large sample bases of sound data - a rare practical occurance(sic)

--Not applicable.

-- I can apply EWMA Technique and Holt-Winters Method, maybe adaptive forecasting to my new responsibility.

-- Effect of smoothing constant.

-- Zip.

--Forecasting bookings & billings via exponential smoothing.

-- Basic ideas substantiated knowledge already acquired and reinforced decision to use these techniques.

-- The general concept of exponential smoothing using trend and seasonality is directly related to the forecasting software package we use.

-- Basic formulations may help in addressing forecasting problems. Not sure how far I could get without further reading, however.

-- The adaptive forecasting part was valuable. However, it was too short.

-- Lagged autocorrelation (?)

Responses to Question: How might this course be improved?

-- Applications requiring judgmental assessment of model.

-- In general, the course was too easy for me. I would prefer a more theoretically oriented course.

-- More practical discussion of forecasting techniques and use of the computer.

-- More handouts.

-- Give additional time to forecasting fundamentals. Get away from theoretical to practical examples. Use real data or participant supplied data as examples. Have students participate more -- need more of a workshop atmosphere. Definitely provide more time.

-- More practical. More organized. Faster paced and shorter.

-- More theory. Prerequisites for admission to course. The prof. should prepare a lecture!

-- Make clearer which parameters are derived (and how they are derived) and which are estimated (& the bases for the values chosen.)

How might the course be improved? (Cont'd)

-- The course was not aimed at me. It was too technical and too quick. By the time I had assimilated material we were long past it.

-- More down-to-earth explanations -- too much theory.

-- Due to the mixed-education background and work experience among the audience, it seems lacking the interation between the instructor and the audience. I would like to see the pre-req. be enforced as the condition to enroll in this course.

-- Take it out of the theory level and discuss it in layman's terms.

-- Take out the Greek and use English language descriptive nouns.

-- More exposure to smoothing/forecasting technology from signal processing theory.

-- More time on the computer.

Other remarks?

-- I can justify a weekend short course to myself easier than weekday courses to my company.

-- Keep me posted on course offerings.

-- I have had 3 graduate level statistics courses from a psych. dept. and an MBA which also required statistics. The course description said that a person should have some familiarity with statistics. I even called the instructor who said that as long as I understood standard deviations and correlation, I'd be fine. Well I wasn't. I wasted a day and the tuition.

The course should have been billed as one for people actively using exponential smoothing methods or (those with ?) advanced statistical backgrounds. The pace was much too quick for someone who was unfamilar with the topic. It was not broadly aimed at general business problems. I'm sure an analysis of questions asked would show a great prep_onderance revolving around academic oriented technical questions (both in numbers and time spent) rather than applications or problem-solving questions. The course was probably of value to some people but not to me. As a result I will certainly be more cautious in selecting or recommending future options. P.S. I might add that this course was described as being for business people and not exclusively for engineers. P.P.S. The instructor made poor use of the time he had. For example, he got a late start and then got hung up in the description of his multi-colored syllabus and the rest of the day he was pushing trying to make up lost time.

As I get worked up again (I had mellowed out since June 27 I remember one of his statements early on where he decided not to cover some very basic information like when or how should I forecast, what is special about my data, etc. He said the material had been covered in a previous courses and that there were some familar faces so he wouldn't bother to go into it again. I was not a familar face.

-- The course was advertised as directed toward the non-technical individual. It was not. The course could provide information for a technician adequately. There still remains a real need for a forecasting system for the non-engineer.

Responses to the Question - I would like to participate in a short course on:

-- Any signal detection, process, tracking, prediction, filter. Any coding information theory.

-- Keep me posted on course offerings.

-- Forecasting techniques like time series analysis (i.e. Box-Jenkin & adaptive forecasting technique.

-- Basic forecasting.
-- Other forecasting techniques- demographic - economic.

-- technology forecasting (substitution, growth curves, etc.)

EVALUATION OF THE EARTHQUAKE ANALYSIS OF MULTISTORY FRAME AND SHEARWALL BUILDINGS COURSE OFFERED BY UNIVERSITY OF CALIFORNIA, BERKELEY, APRIL 30 - MAY 1, 1979.

(Kenneth Wong, Ph.D., Faculty Member In Charge)

Evaluators: Martha Maxwell, Ph.D., N.S.F.
Project Director

Carolin Showers, M.S.,
Research Assistant

The material in this report is based on work partially funded by the National Science Foundation under Grant No. SED-78-22138. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Background & Purpose of the Course

The National Information Service for Earthquake Engineering (NISEE), sponsored by the National Science Foundation (NSF), distributes computer programs for earthquake analyses of structures. These computer programs (or codes) are developed at universities (primarily at U.C. Berkeley) under NSF grants. Codes can be purchased by the public from NISEE for $125-$250.

The purpose of this course is to describe four computer codes for earthquake analyses, to relate practical experience in their use, and to demonstrate the problems for which they can be successfully applied. The course serves both as a way to advertise codes to engineers, especially those in small companies who are unfamilar with them, and to update the understanding of engineers in larger companies who have already purchased and are currently using the codes. The course coordinator made special efforts to encourage present owners of the codes to attend so they could improve their understanding of the types of problems for which the programs should and should not be used.

The coordinator expects that participants in the course will have varied experience and background. Most are expected to be structural engineers, involved in the design and analysis of buildings who have had some experience with computer applications in structural design but not specifically with programs geared to earthquake stress analysis. The coordinator anticipates that architectural engineers and state and city engineers who oversee building design will also attend.

In order to profit from the course, the instructors expect participants to have some background in fundamental building analysis, at the level of an undergraduate course in dynamics.

The six speakers were chosen because they participated in writing the codes taught during the course. Four are from academic backgrounds -- two University of California Berkeley professors (Wilson and Powell) and two of their former students (Row and Hollings). The other two instructors are practicing engineers who have a great deal of experience in applications of the codes (Habibullah and Fintel).

The course is organized in four parts by the computer codes: (TABS, ETABS, DRAIN 2D and DRAIN-TABS) Instructors introduce each code, give examples of its applications, and discuss the limitation of its use in certain problems.

Input manuals for each of the four codes, including a brief explanation of the theory for each, comprise the course materials. In addition, materials showing actual examples of how to use the codes are given out.

After attending the course, participants are expected to gain experience by using the programs in their design work, gradually learning the types of problems to which the codes can be successfully applied.

Results of the Evaluation

Questionnaires were passed out to participants on the last day of the course and returned by 49 people of the 50 who enrolled in the class. Eleven students were interviewed by phone one to two months later.

Student Characteristics

The student group had very applied interests and work primarily in structural design and analysis. They are fairly well-educated, with degree level split evenly between Bachelor's and Master's with just 3 Ph.D.'s. Most (63%) received their degrees after 1965 and spend more than 90% of their time in technical duties. Half say that their work has involved earthquake engineering for more than 5 years. Most had performed computer analyses before taking the course and applied computer results to building design. Forty-three percent have written applicable computer codes while 10% had no previous experience with computer programs.

Most people came on their own initiative, while 24% came at their supervisors' suggestions and 18% were selected by their companies. Eighty percent had their expenses paid by the company, while 42% received released time, and 27% noted that their companies strongly encouraged attendance.

Student Evaluations

Most participants say they took the course to learn and update their information on computer applications. Students felt that the goals of updating applications and meeting others were well satisfied. Those who wanted to learn new applications and gain perspectives for decision-making were somewhat less satisfied with the course. Most people were interested in the TABS and ETABS programs, and a majority of persons felt that they could use information gained about these immediately. Fewer people felt they would use the DRAIN models immediately although the majority said they might use them in the future.

Seventy-two percent said the course pace was about right, while 21% found it too fast. The instructors' emphasis on fundamentals, applications, theory, and research was judged about right by most people. The only significant deviation was that 30% felt there was too little emphasis on applications.

The average attendee said he might use the course materials while 39% said they plan to use them regularly.

Most (82%) felt the course had benefited them professionally and that their companies would benefit somewhat from their taking the course. They gave a long list of reasons.

Half of the group plan to take additional courses. Most plan to discuss the information with their colleagues and about half will talk to their supervisors about it. (Most students (87%) said they would recommend the course to a colleague.)

Thirty five people made suggestions for improving the course. The most frequent comments were on the need to make the course more applicable for practicing engineers (e.g., more information on the pros and cons, costs, etc. of different programs) and increasing the length of the course (e.g., following it with a hands-on workshop). Also suggestions were made on improving the materials (e.g., including sketches in the hand-outs, sending materials out in advance of the course, etc.). Some indicated they had problems following the talks of some of the lecturers (e.g., they jump about too much).

Information from some of the interviews illustrate the different ways participants viewed the course and how they are making use of the information they learned.

Case #1 - a president of a structural consulting firm who had used a variety of programs for structural analysis, but was not familar with quake modeling before taking this course. He feels his knowledge has improved, he has used TABS twice, and hopes to use the programs more because he finds them easy to use. He has been designing high rises for a long time, so his mode of design will not change, but the computer programs will assist in making preliminary analyses. He feels these programs are the first that are cheap enough to use in actual design process and are more efficient time-wise compared to long-hand calculations for a 30-40 story building. He states he will probably go ahead with using a static loading but thinks a dynamic loading would give greater deformation although he's not too confident about the use of dynamic loading as input. He's used the course notes only for TABS and says using DRAIN is premature. He felt the instructors in the course gave impressive presentations and appreciated the discussions of computer methods when long-hand calculations were presented side-by-side with computer programs. He needs this to justify the use of the programs in consulting.

He feels the DRAIN (inelastic) programs are not useful because the physical processes are not well understood and clients would not see the results as being reliable. He says the main benefit of the course was to get programs which he can use economically. He thinks the course could be improved if there were work sessions for individuals to run sample programs themselves.

Case #2 - a director of research and development who felt he did not have much preparation for the course but wanted to know how to use the programs. He feels he gained a lot of information but found too many things were missing in the programs. Since taking the course he has tried to set up a program but found it impossible. He drove the data to the nearest university where the computer department told him the job was impossible to run on their machine. He's upset that he wasted material and time.

He complained about the errors in the programs and the examples and felt that the speakers did not outline the capabilities of each program - do's and don'ts. Also he was unhappy because there was no explanation about the numbers/notation system used on the printouts.

He would like the programs to be available for remote terminals and modified so they would take a smaller line (80 characters vs 132). He wants programs that are more flexible so that they could be used with small computers and suggests that programs should take into account small and moderate sized buildings. (He designs 5-10 story buildings.) He feels that the course should be divided into two sections, for beginning and students advanced and scheduled for a longer period with more hands-on time on the computer. He feels the programs require major rewriting to be useful to his company.

Case#3 - a civil engineer who was familar with the subject matter, but not with the computer programs before taking the course. He feels he would have gained more from the course and understood more if he had some experience and hopes to have time this summer to become more familar with TABS. He has taken an earthquake analysis course offered by the Structural Engr's. Association.

He says he has no need for the programs in his work. His firm designs hydroelectric projects and does not do too much structural design. Although he expects to use the TABS program eventually, he feels the other programs are too sophisticated.

He complained that the notes used symbols which were not defined in the notes; and thinks the notes should include a simple example done both in the long-hand method and by computer. He feels the notes could have been more graphic.

He would like to take a longer course and commented that "Where elso could an engineer learn this without taking a M.S. at Cal.?" He feels a semester length course would be good because students need time to ask questions and work through the computer programs on their own.

He felt the main benefit of the course to him was that it introduced him to uses of four programs and that he learned about programs available from other companies. He expressed surprise at how inexpensive the programs are to use and liked the opportunity to get together with other structural engineers, to ask questions of the people who wrote the programs, and to learn what information NISEE distributes, and the problems other users had.

Summary and Recommendations

The course was successful in that most of the participants were satisfied that it gave them a good introduction to the computer codes available for earthquake analysis of shearwall buildings. As is true in other CEE courses, many students who completed this course expressed a desire to take more intensive courses on the topics presented - e.g., a longer, hands-on workshop. About half of the students wanted a longer program, and most of the suggestions for improving the course would involve lengthening it or providing alternative sections for beginning and advanced students (i.e., more in-depth opportunity to work out problems with the computer, more opportunity to talk with others who are experienced in using the codes. etc.).

In general, the course appears to meet the needs of the students who take it, however, the faculty member-in-charge and Extension might investigate the feasibility of offering a longer course, alternative sections for beginning and advanced students, and/or a hands-on workshop as a follow-up to this short-course.

[ ] [ ] [ ] [ ]

EARTHQUAKE ANALYSIS OF MULTISTORY FRAME AND SHEARWALL BLDGS.

Questionnaire

N = 49

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its short courses for engineers. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

5. What is your job title?

Your highest academic degree? BA/BS=23; MS/MA=21; Ph.D.=4

Year? 76-79 = 10
71-75 = 10
66-70 = 10
61-65 = 2
boorlrss = 16

6-8. What % of your time is spent in:
Average [11] managerial duties
[87] technical duties
[2] sales/marketing

9-12. Do you work primarily in:
[64%] Design & analysis of structures
[10] Computer program development
[13] Computer applications
[13] Other (specify)

13. How many years has your work involved earthquake engineering?

%	1-2	2-5	6-10	11-15	16+ yrs.
	13	27	31	6	23

14-18. How much experience have you had in using computer analysis techniques for designing buildings?
[41%] Have written applicable computer programs.
[71%] Have performed computer analyses.
[76] Have used and interpreted the results of computer analyses.
[4] Have had other experience. Explain.
[10] Have had no experience.

19-22. What were your goals in taking this course? How well were they achieved?

%		not at all	somewhat	very well
[66]	Learning new computer application to earthquake engineering	[2%]	[58%]	[40%]
[64]	updating knowledge of computer applications to earthquake engineering	[5%]	[49%]	[46%]
[33]	perspectives for decision-making	[15%]	[50%]	[35%]
[34]	meeting others in the field and finding out what they're doing	[5%]	[50%]	[45%]

		Did you find anything in the course that you could use immediately? If so, what?	Did you find anything in the course that you can use in the future? If so, what?
23-24.	TABS	53%	31%
25-26.	ETABS	41	27
27-28.	DRAIN 2D	14	27
29-30.	DRAIN-TABS	10	22

(On the reverse side, briefly describe the ideas and techniques you found most valuable and how you used them.) (See list attached)

31. How did the pace of the course suit you? [23]% too fast [73] about right [4] too slow

How would you rate the instructors' emphasis on the following?

		too much	about right	too little
32.	fundamentals	[4]%	[82]%	[14]%
33.	application	[2]	[69]	[29]
34.	theory	[10]	[78]	[12]
35.	current research	[10]	[73]	[17]

36. How did this course compare with other engineering short courses you have taken? (in usefulness, content, interest)
    - [40%] the best I have taken
    - [28] better than others I have taken
    - [38] about the same as others
    - [15] less satisfactory than others
    - [15] have taken no others

37. Who initiated your decision to attend this course?
    [67]% you [24]% your supervisor [8%] selected by company
    (some checked more than one)

38. How does your company support/recognize attendance at courses like this one?
    - [29]% company strongly encourages attendance
    - [96] company pays fees and expenses
    - [41] company grants released time (time off)
    - [8] course attendance increases possibility of promotion/raises
    - [6] no particular encouragement

39. Do you plan to seek further instruction or do further individual or company research on the topics in this course?
    - [8%] major company research area
    - [51] plan to do considerable research on my own
    - [47] plan to take additional courses
    - [8] no

40. Do you plan to discuss the information gained in this course with your company colleagues? [80% supervisor? [51%

41. Will the course materials be useful to you in your work?
[39% expect to use them regularly [55% may use them
[6% doubt that I'll use them.

42. Do you think that taking this course will help you professionally?

If so, how?

Yes = 82%
No = 6%
Somewhat = 12%

43. How much will your company benefit from sending you to this course?
[18% a great deal [78% somewhat [4% not at all

Explain:

44. Would you recommend this course to a colleague? [15% no [82% yes

45. What one suggestion do you have for improving this course?

33 suggestions

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

[ ] prefer telephone interview
[ ] want further information
[ ] do not wish to participate

I do [ ] do not [ ] wish the information I give to be released to my company.

[ ] Please send me a summary of the final report.

WRITTEN QUESTIONNAIRE RESPONSES

Q.1. What is your job title?

Staff

3 Engineer
Engineer II
3 Structural engineer
2 Project engineer
5 Civil engineer
Design engineer
Designer
1 Structrual designer
2 Chief engineer
Consulting engineer
Research engineer
11 Senior structural engineer
2 Associate engineer
Associate research engineer

Managers

2 Project managers
Computer Department
Chief, Structural Engineering

Directors

Vice-president
President

Other

Student
Professor

Q. 23-30. Briefly describe the ideas and techniques you found most valuable and how you used them.

1) Response spectrum and static analyses are techniques which I intend to try to use on future projects.

2) Clarification on the details of the software construct--very useful in trying to adapt complex models for use in analysis.

3) The most valuable idea is that the dynamic behavior of the computer models is more dependent on the input ground motion than on the type of program or the elements of the structural model. Therefore, since the real earthquake will not perform per any specifications, I had better ignore detailed computer analysis as a source of design decisions and design per U.B.C. with all its "inaccuracies".

13) Learning the restrictions of TABS.

15) I would be very interested in further courses that include other multi-purpose programs--SAP, EASE, etc.

24) Course serves as a basic introduction to the use of these programs.

28) This two-day seminar reinforces some thoughts which I have experienced from time to time, namely that the structural engineer is not paid commensurate to the expertise that he is required to have in order to practice his profession. He is too busy chasing the state of the art and working, and so far hasn't taken the time to beat his own drum and carry out a P.R. campaign to let the public know his worth. UC research is necessary to improve earthquake engineering, but we may all drive busses if the structural engineer's relative worth isn't advertised. (Opinion.)

30) The main important idea to me is to realize the limitations of TABS. It is essential to know what is not allowed in modeling, and what is not a good idea to do.

37) We use TABS and DRAIN-2D occasionally (usually SAP). This course gave some good modeling hints and techniques. Also, I gained a greater appreciation for the limitations of these programs and I'll be more careful and aware.

48) TABS & ETABS presentations were a disaster! Drain 2D was excellent by Powell. In any case we feel spending so much research money without having the remote terminal use possibility is wrong, especially for average pur shearwall bldgs. where the number of D.O.F. is small.

Q.42. Do you think this course will help you professionally? If so, how?

Yes = 26; No or not very much = 3; Possibly = 1

Yes - Any exposure to better technology in this field helps you professionally.
- To avoid errors.
Enables me to verify design by computer modeling should job/client indicate.
- because (it will enable me to make) fast decisions and fast results in my profession.
- by applying computer programs.
- the information was directly applicable to my job.
- in my favorite field.
- develop structural models.
- becoming increasingly familar with these programs will help me decide which program to use.
- better understanding of capability of programs.
- as knowledge of structural behavior of buildings increases more design emphasis will be needed to use this knowledge. This class helped me gain knowledge I can use.
- It will enable me to solve design problems in a better manner.
- There have been many developments since I graduated in '72.
- To use available computer programs for building design.
- but not in the immediate future.
- to further my background in the state of the art research and application of structural engr. programs.
- 2 have not had previous exposure to Berkeley programs which are generally accepted by the engineering field.
- current analysis procedures help design and productivity. It gives a better view of analysis techniques that are available.
- I gained insights that will be useful in technical analysis and review of dynamic analyses and in government contracts.
- it increases my range -- what I can do.
- it may improve the efficiency of my department through the use of these programs.
- gives me more tools.
- by keeping up with advancements.
- broadened my knowledge in codes other than Sap4 and gave me a better concept of non-linear behavior.
- I know the capabilities and limitations of TABS & ETABS.
- The knowledge of current research and use of computer programs is important to structural engineers.
- We use computers all the time and increased familiarity with these types of programs can only help.
- Now have a basic understanding of dynamic application.

Not unless I pursue better explanations by better course presentations.
Not very much - need instructors who are better prepared & generally better at their jobs.
No - not much for now - there is no direct applicability at this time.
Possibly - get a job and/or start my own outfit.

Q.43. Continued

- The supervisors all are very familar with these types of programs and the assumptions involved. It will only help me.
- older members of the office feel less comfortable with computer programs. They would like someone to be able to understand them.

Not at all - not enough practical explanations and applications presented to benefit my company.
- The goal of my company in sending me to this course is to develop a skill using minicomputers to solve structural design and not using existing programs.

Q.43. How will your company benefit from sending you to this course?

Ans.: A great deal = 7; Somewhat = 16; Only a little = 1; Not at all = 2.

May improve the efficiency of my department through use of these programs.

A great deal - I will pass this information on to all others in our firm.
- We're in the process of developing computer analysis.
- No one at our company is that familar with TABS.
- it will improve the capability in earthquake design.
- the use of these programs is increasing.
- we are on the threshold of designing major concrete ductile frame building (40 stories high and up to 60) and need to understand and perform sophisticated analysis to increase judgment and capability.

Yes - I became aware of alternatives and realize that we do not have in-house capabilities to use programs.

Only a little.

Somewhat - knowledge of current research analysis techniques are important to our program.
- the supervisors are all very familar with these types of programs. The course will only help me.
- many of our current projects are too small for these applications or they're made of wood.
- the cost of course is so high that it will be a long time before my benefits from using what I learned outweigh cost.
- there is no direct applicability at the present time.
- we use, or will use, these programs occasionally.
- our company product is not directly related to computer programs.
- I'll hold in-house seminars.
- we don't design many high rise buildings in our office.
- I suspect the time required for learning input/output data will be reduced.
- only a small % of our work involves structural design.
- We would usually pay Oshraf to do this!
- it will increase our capability.
- I will be able to be involved in inelastic analysis projects.
- We use TABS & Drain 2D occasionally (usually SAP). This course gave some good modeling hints and techniques. Also I gained a greater appreciation of the limitations of these programs & I'll be more careful and aware.

Q.45. What one suggestion do you have for improving this course?

1) Spread it out over many evenings with access to computer to experiment and become familiar with software discussed.
3) Make it less expensive. (69 participants x $225 = $15,525)
4) Send notes beforehand for familiarity.
5) The speakers describing the input and output must be more professional than academic--to keep interest in listening and understanding.
7) There should be long-term courses emphasizing applicability of computer programs.
8) Add workshop for actual usage of programs.
9) Seems OK--next would be workshop.
10) Write brief explanations on computer sheet.
11) Provide more background information relating to previous developments by MTS leading to present state of art for better continuity.
12) A bit more background in fundamentals.
13) Find a better location.
15) More practical application of modeling techniques.
19) Better preparation of reference material.
20) More emphasis on useful tools.
21) 3 days instead of 2.
24) Examples should be of a smaller size so we can take examples into our office to test run.
25) More emphasis on topics not covered in manuals--advanced problems, program characteristics, (stiffness degradation)--distribute manuals prior to course so basic information would not have to be covered in such detail.
26) Lower cost to make available to more people.
27) I had problems relating a practical use for "Drain" in its current state of development.
28) Put audience in the ballpark when subject matter is changed. Several speakers were so involved in their topics that they were difficult to follow. When speakers jump around, they tend to assume audience has same familiarity with topic or example problem that they do. A little more qualifying would be useful.
29) More examples of modeling and modeling techniques.
30) For me, the info. on DRAIN was good for background, but too much time was spent on it compared to its practicality.
31) More streamlining, better preparation of lecturers.
32) The sketches to the distributed computer output should have been copied.
33) None!
35) Course should emphasize more the benefits to practicing engineers.
37) Stress modeling techniques, but not actual "how to input." Anyone can read the manual for input.
41) More than 2 days.
42) More and slower presentation on non-linear behavior and program assumptions.
43) Get practical engineers to present material.

Q.45. (Continued)

45) One day longer (3 days).
46) Present information on the pros and cons of various programs available to the practicing engineer, e.g., cost comparison of several commercial programs, presented somewhat like a consumer guideline.

Present useful information of damping values to various types of structures that a practicing engineer may encounter. Techniques on smoothing a response spectra that is attained from a soils engineer for input into a program. In other words, basic practical techniques required by the analyst to perform a response spectrum or time history analysis.
47) Instructors who are better prepared and generally better at their jobs.
48) Emphasize basic assumptions. Do's and don'ts. Also how to use TABS, ETABS for shearwall bldgs. (no frame). Also gear TABS for terminal users.

Suggestions From Interviews

1. Found there were problems with sign conventions in math models and a few things that weren't included in the UCB programs (e.g., can't include cantilever structure in program).

A better way to present information is to have a work session for individual to run sample problem himself.

The DRAIN (inelastic) programs are not yet useable because the physical processes are not well understood. A client would not see the results as being reliable.

2. A semester-long CEE course on similar topic. Need good first-hand knowledge of topic to get a lot out of a short course. Need a longer course. Someone commented that "Where could an engineer learn this without taking a MS at Cal?" A semester CE course would be good - need time to ask questions and work through computer programs on your own.

3. 94% of the instructors and people are from California and already aware of programs (he's from Colo.) and the class should last longer because we need to get on the computer. Programs presented are powerful for large buildings but neglect small and moderate-sized buildings. Programs should be more flexible so they can be used with small computers. (I design 5-10 story bldgs.) The course needs to be divided into two seminars - one for beginners and one for advanced people.

4. Might spread course out over evenings for several weeks so everyone could try out programs in between.

5. Possibly publish a booklet - may not be possible because field changes rapidly.

6. Information presented did not always follow notes - did not tie together well.

7. Physical set-up was very good, but should have some time for engineers to discuss between 1st and 2nd day. People who had to catch planes on the second day did not have time to ask questions.

8. Biggest handicap was getting up in a.m. We should have better directions to get to class.

9. Need more convenient location and lower fee (I'm a private consultant).

10. Limitation in computer programs, could be pulled out of context and delineated better.

11. The inelastic development was useful only as knowledge and not very practical now (these take too much computer time, and are useful only in research, not design). I could have skipped that day.

12. Still a little too much like a textbook, but that was due to lack of time.

EVALUATION OF THE ENGINEERING DESIGN IN TIMBER COURSE BY THE UNIVERSITY OF CALIFORNIA ENGINEERING EXTENSION DEPARTMENT July 18-21, 1979

Evaluators: Martha Maxwell, Ph.D.
NSF Project Director

Rick Boettcher,
Research Assistant

Engineering Design in Timber is a 3½-day course intended for engineers and architects who possess a general knowledge of structural theory and design problems but who need the specific technology of designing in timber. The course covers strength of timber in relation to grading and use, and the particular way in which timber properties affect structural problems, including use of sawn timber, plywood, and glued laminated construction. Lectures include the grading and production of timber and glulam; beams, columns, shear walls and diaphragms; timber connectors and structural systems.

Professor Jerome M. Raphael, University of California Structural Engineering and Structural Mechanics, was the faculty coordinator, assisted by four instructors -- Thomas E. Brassal of the Institute of Timber Construction, Stephen A. Mahin of U.C. Berkeley, Ron Sanchez of the American Plywood Association, and Kenneth D. Smetts, a consulting structural engineer.

This evaluation is based on the responses of 28 students who filled in a questionnaire on the last day of the course and on telephone interviews with nine students called about a month after the course ended.

Characteristics of the Students. A varied group of people attended this course--engineers, professors, architects, draftsmen, sales personnel and others. Nineteen were college graduates and 8 had earned a master's degree. The average student completed his last college degree in 1968 and has worked in timber design for over 5 years. However, there was a 30-year range with 40% of the group having less than one year's experience in timber. Most enrolled in the course on their own initiative and with company support.

Student Evaluations. Most students took the course to improve their general background and increase their skills and felt the course met these goals well. Those who were interested in learning fundamentals rated the course as succeeding fairly well, but those interested in acquiring a perspective for decision making or meeting others in the field rated it only somewhat satisfactory. Overall those who had taken other short courses rated this one as slightly better than other courses they had taken. The average student felt that he was well prepared academically for the course in theory and fundamentals, but less well prepared in practical experience.

This project was funded by the National Science Foundation under Grant #SED-78-22138. The opinions, finding, conclusions, and recommendations expressed are those of the authors, and do not necessarily reflect those of the National Science Foundation.

Most students found something of practical use to them in the course. Plywood technology was seen as most useful immediately and the glulam information as more useful in the future than other topics. Most rated the instructors' emphases on research, theory, and fundamentals as about right but felt there was not enough emphasis on applications. Most say they will use their notes and the course handouts regularly.

Forty-one percent of the class plan to take other courses on the topics of this course and 29% plan to do considerable research on their own. Most felt the course helped them professionally and 67% said they would recommend the course to others. Those who would not recommend it said that it was not applied enough.

Student suggestions for improving the course included passing out outline notes of the lectures ahead of time, including more information on problems and solutions with real world applications (for example, designing a house showing all connections) and extending the course for another day. Others suggested that the speakers go into more depth on some topics--which would require a longer course. One suggested that the speakers be videotaped and that the overhead aids be xeroxed for the students.

Information from the interviews illustrate the widely different needs of the students:

Student A is a senior structural engineer who supervises 8 people and works for the state of California. He felt his preparation in theory and structure was above average, and took the course to improve his technical information, and to learn more about costs. He feels the course helped him quite a bit. Prior to this he took courses given by the American Plywood Association and one on pre-stressed concrete given by BART. He rates this course the best he has taken. He has shared his notes and handouts with his 8-person staff and brainstormed with them about ideas from the course. He took notes and has used them. He feels he's better informed about the state of the art as a result of talking to the consultants and listening to the presentations. He enjoyed the course very much and says he will take it again in two or three years. He suggests having a dinner and speaker.

Student B has been a professor of engineering for 32 years but has never taught a timber course. He went into this course cold except for theory and basics. He will teach a course in design in a year and wanted to prepare himself. He has taken a related course at UCLA Extension and was impressed that the UCLA course was better organized and that the professor distributed course notes. He felt Raphael should have had more sample problems, but that he was just not prepared--"he's well qualified, but not adequately prepared with materials." He said this course had a good balance between industry and university people. His major complaint is the lack of notes. He doesn't like to take notes madly and would like to have them given out to students. He rated the course as about the same as other courses he has taken although he said he did learn how to begin to design timber structures.

Student C has no experience in timber design and said he was starting from zero. He works in structural engineering, but does not work much with timber. He took the course to prepare for the state Structural Engineer Exam and thinks he did pretty well on the test. If it hadn't been for the class, he says he would have been in dire straits to pass the exam. The only related course that he has taken was on the design of offshore structures. He would like to have xeroxes of the overheads. He felt the instructors were well prepared but varied in their ability to answer students questions, and thought that Smetts assumed a lot of knowledge on the part of students. He was very well satisfied with the course, and rated it better than other short-courses he has taken.

Summary and Recommendations:

The students enrolled in this class differed widely in background, experience, interests and their reasons for taking the course. Most were satisfied that the course helped them improve their understanding and updated their knowledge of timber design, as well as giving them some ideas/techniques that they could use on their jobs. The main complaints were that some of the speakers did not emphasize applications enough particularly the academic instructors, who did not present enough practical examples, problems and solutions to illustrate the points in their lectures. Also there were complaints about the need for course notes and additional materials.

Since this was the first time this course was offered, there is room for improvement. The following are some suggestions:

1. Speakers should prepare examples, illustrations, and practical problems to illustrate their concepts so that the practicing engineer students can relate to and understand the information they present. A significant number of the students in this class have no experience in timber design and cannot make the transfer from theory to practice without explicit examples.

2. Course materials should include outlines of the presentations and copies of the viewgraphs used. Engineers who take short-courses expect and need outlines of the academic/technical presentations. Without outlines, the newcomers to the field have problems following the new information and become frustrated in their attempts to learn. Outlines are especially necessary for presentations on difficult, abstract, or highly technical information.

3. The course seems to meet an important need for people in timber design, and the faculty coordinator should consider ways of changing the course so that it better meets the range of student needs--perhaps by extending it for a half-day or planning some optional sessions where students can choose between basic fundamentals and more in-depth presentations.

JOB TITLES

Number	
5	Civil Engineers
3	Senior Engineers
7	Structural Engineers
2	Professor Civil Engineers
1	Assistant Engineer
2	Architects
1	Bridge Engineer
1	Design Draftsman
2	Sales Representatives
1	Water Resources Engineer
1	Operations Mgr.
1	President, Facility Supervisor

TIMBER

Q. 27. Comments: Was there something you expected to learn but didn't?

-- more extensive lateral analysis (i.e. loading)

-- residential construction

-- shear wall connections

-- structural problems such as: column splices, checked beam shear when proper to use, procedure

-- methodology

-- practical design problems

-- economic aspect of designing with alternate methods

-- more connection details, and want more examples, than theory

-- detailing and design for lateral forces

-- timber piles, timber underground and underwater

-- load design and distribution

1) Practical consideration of detailing connections

2) Pre-engineered truss

3) Good practice in connection design to allow for shrinkage

Q. 52/53. Comments: Will this course help you? Would you recommend it to others?

-- recommend for Area Seniors as update

-- help keep up with changes in code/manufactured prod.

-- prepared to work w/professionals

-- knowledge for decision-making

-- new data in handouts useful

-- help in passing structural engineering exam for Cal.

Q. 52/53. (cont'd)

-- have taught a similar course several times and I wanted to learn how others taught it. Get new information.

-- increase proficiency in design

-- access to resource persons for assistance

-- better understanding of timber design.

Q. 54. Participants' comments: Suggestions for improvement.

-- Strongly urge that all lectures be previously prepared and notes passed out. Very important. Impossilbe to keep up with professor.

-- Typed notes ahead of time, outline. (3)

-- Course geared to building construction. More emphasis should be put on fact that timber is an important material in heavy construction. Its use is subject to other specs such as AASCHO, AREA, etc. There are some differences in applying mechanics.

-- Increase length. (1)

-- Practical applications (3)

-- Instructors had to rush. Some lecturers were too fast

-- Found most valuable the information on glulam design, plywood properties and design.

-- Methodological approach, example, problems needed

-- Should include a sound discussion on problems and solutions

-- Tuition high

-- Give it 2 weekends

-- More practical. Use designers as teachers; less theory-oriented professors

-- Too broad brush: concentrate on specific areas

-- Real world applications needed to make courses more comprehensive

Q. 54 (cont'd)

-- Eliminate Mahin; have Raphael and Smetts do the course almost by themselves with one lecture only from an industry representative Smetts is the most important because he is the only designer.

-- Shorter lectures

-- Spend a day designing a house showing all connections

-- Smetts and Sanchez very good

-- Mahin good

-- Brassel average; Raphael poor!

-- More emphasis on derivation of loads and correction factors.

-- Extend to 5 days

-- Add 1/2 day to pro-engineered truss and economy of frame choices

ENGINEERING DESIGN IN TIMBER
June 1979 Class
Questionnaire
Respondents=28

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its short courses for engineers. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

5. What is your job title? Structural engr./civil engr.=65%;architect-draftsman=15%; sales=10%; other (professional,etc.)=10%

6-8. Your highest academic degree? BS=19; MS=8; 1-HS

Year graduated
Average-1968
Range 1948-1978

9. Have you had any previous courses in timber design?
Yes-9 (32%)

10-12. What % of your time is spent in:

Average (28%) managerial duties
(29%) design
(21%) structural engineering
(23%) other? (specify)

13-14. For how many years has your work involved timber design?
average= 5.3 yrs, Range 1 to 30 yrs 75% had less than 5; 40% less than 1.

15-20. What were your goals in taking this course? (Rank order. 1=most important, through 5=least important.)
% rating each goal as most important. Note some rated more than one as most important

(21%) learning fundamentals of a field new to me
(54%) improving general background
(50%) updating technical knowledge
(4%) acquiring a perspective for decision-making
(4%) meeting others in the field and finding out what they're doing
( ) other (explain)

21.-26. How well did the course satisfy your goals? (Check)

#		Not at all	Somewhat	Fairly well	Very well
27	Learning fundamentals	( )	(33%)	(41%)	(26%)
26	Improving background	( )	(15%)	(58%)	(27%)
27	Updating tech. knowledge	(7%)	(15%)	(45%)	(33%)
26	Acquiring perspective for decision making	(7%)	(35%)	(35%)	(23%)
22	Meeting others in field	( )	(64%)	(32%)	(4%)
	Other (what?)	( )	( )	( )	( )

27. Was there something you expected to learn in this course, but didn't? If so, what? Yes 46% (See list)

28-30. How well prepared were you for this course in the following:

	average (1=poorly; 3=well)
theory	2.4
fundamentals	2.5
practical experience	1.8

	Did you find anything in the course that you can use immediately? If so, what? #	Did you find anything in the course that you can use in the future? If so, what? #
31-32. Wood Species & Grading	17	6
33-34. Sawn Timber Beams	17	5
35-36. Glued Laminated Beams	14	9
37-38. Glulam Systems	13	11
39-40. Plywood Technology	21	5
41-42. Columns	14	4

On the reverse side, briefly describe the ideas and techniques you found most valuable and how you used them.

(See list)

How would you rate the instructors' empasis on the following

	too much	about right	too little
43. current research	(4%)	(85%)	(11%)
44. fundamentals	(19%)	(78%)	(3%)
45. application	(4%)	(44%)	(52%)
46. theory	(4%)	(81%)	(15%)

47. How did this course compare with other engineering short course you have taken? (in usefulness, content, interest)

(11%) the best I have taken
(28%) better than others I have taken
(36%) about the same as others
(21%) have taken no others

48. Who initiated your decision to attend this course?

(75%) you (11%) your supervisor (14%) selected by compay

49. How does your company support/recognize attendance at courses like this one?

(25%) company strongly encourages attendance
(71%) company pays fees and expenses
(36%) company grants released time (time off)
(4%) course attendance increases possibiliy of promotion/raises
(14%) no particular encouragement, paid my own way

50. Do you plan to seek futher instruction or do further individual or company research on the topics in this course?

(14%) major company research area
(29%) plan to do considerable research on my own
(41%) plan to take additional courses
(18%) no

51. Will the course materials be useful to you in your work?

(68%) expect to use them regularly
(29%) may use them
(3%) doubt that I'll use them

52. Do you think that taking this course will help you professionally? If so, how? Yes-25 No-3

53. How many others in your company/branch work in timber design? Average 3.6 Would you recomment this course to them? Yes-67% No-33% (because it lacked practical information.)

54. What suggestions do you have for improving this course?

(See attached)

Other remarks?

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below:

Name_____

Phone No._____
(area code)

( ) prefer telephone interview
( ) want further information
( ) do not wish to participate

Evaluation Report on the U. C. Extension Computer Aids for IC Technology and Device Design Program Held July 9, 1979

Martha Maxwell, Ph.D., Evaluator
Rick Boetcher, Research Asst.

Questionnaires were mailed on August 29 to a random sample of 100 participants who enrolled in the July 9, 1979 U. C. Extension Program on Computer Aids for IC Technology and Device Design. This report summarizes the responses, of the 52 people who replied to the questionnaire. The number of people responding is small, and may not represent the views of the total group of 300 who attended the program, therefore the results should be interpreted with caution.

Characteristics of the Participants

The respondents represent a highly educated group about equally divided between those holding bachelor's, master's and Ph.D. degrees. They completed formal education over a long time-span -- between 1949 and 1979 with the average graduating in 1972. The average respondent has worked in his present specialty 5½ years and spends about 20% of his time in administrative duties, 50% in research, and 20% in production or other. Only one is a full-time administrator while nine are full-time researchers. The average respondent supervises one or two other employees.

Seventy-two percent of the group said they were familiar with SUPREM before taking the course, 60% had used it, and 80% plan to use it in the future.

Sixty-five percent said their attendance was self-initiated and 35% were selected by their companies to attend the program. Program fees and expenses were paid for by their companies in 98% of the cases. Twenty percent reported that they were the only representative of their company who came to the program, while 16% stated that their company sent more than 10 representatives.

Seven people had taken the course before and 4 of these said there was enough new information to keep them interested.

Thirty-five percent felt they were well-prepared for the class while 27% felt unprepared. Sixty-three percent said that it would have helped them if course materials and notes had been sent to them in advance of the program. One said that he felt very well prepared because he had read the materials and notes from last year's program and discussed it with colleagues who had attended it. Some said that having course materials in advance would also improve the questioning period.

This project was funded by the National Science Foundation under Grant # SED-78-22138. The opinions, findings, conclusions, and recommendations expressed are those of the authors, not NSF's.

Thirty-four percent found all of the topics presented would be useful in their work, others found several topics useful. Only one respondent replied that nothing from the course could be used in his job.

Seventy-two percent said they were familiar with SUPREM, 60% had used it, and 80% plan to use it in the future.

Participant Evaluation

The average respondent was very well satisfied that the program achieved their goal of getting an overview of current research. On the average, respondents were less satisfied that the program met their other goals -- i.e., learning fundamentals, learning current theory, and solving process-problems. These they rated as only "somewhat" attained. Those who expected to learn to solve process problems were the least satisfied. Also those who were interested in meeting or contacting others in the field were disappointed as there was little time for this (e.g., a video-tape was shown during the lunch hour.

Although 54% of the group thought the program description was accurately stated, six of these said the program title was incorrect because it implied that the instructors would spend more time and put more emphasis on process modeling and the computer aids than they did. Fifty-eight percent of the respondents said they expected to learn something other than the program offered. (This represents a much higher percentage of unmet participant expectations than we have found in other CEE short-courses.)

One outcome of CEE short courses is that they stimulate participants' interest in learning more about the topics presented. This course was no exception. Participants gave about 40 topics on which they would like to see Extension plan courses. Perhaps the large number of responses to this question reflects the frustration of those who attended primarily for process modeling information and found minimum emphasis on this.

Participants made a number of suggestions for improving the program. Complaints centered around two areas -- the limited time devoted to process modeling and computer programs and the course materials. Thirty percent of the group, including a large number of Ph.D. participants, complained about the lack of detailed outlines of the lectures -- saying that it was impossible to take adequate notes of the fast-paced, technical presentation. Perhaps they have a greater need for the details of the experimental information in their work or perhaps they learn best from reading. Others complained that the materials given out in the program were not related to or did not follow the content of the lecture. Although 29% of the respondents felt the course materials would be very useful in their work, 27% considered them of little or no value.

Some participants were deeply disappointed, others angered at the long delay in receiving lecture notes promised by the program coordinator.

Summary

Participants in this course were highly educated, experienced engineers with a great deal of interest in the course topics and a desire to learn more. Those who expected to get an update on Stanford's latest research in IC Technology were well satisfied; but those who were interested primarily in device design processes and in learning more about the computer aids were unhappy with the limited time spent on these topics. Other than the complaints about the course materials, most suggestions were directed at providing more information on some or all of the topics addressed in the program -- suggesting that the program could be lengthened.

RECOMMENDATIONS

1. Course Title. Either the title should be changed to something like A One-Day Symposium on Current Research in IC-Technology, or if the current title is used, more instructional time and emphasis should be given to process-modeling and the computer programs.

2. Improve Course Notes and Materials. Detailed, hard-copy outlines of the lectures should be given to each participant at the start of the program. Copies of all viewgraphs should be included in these materials. If these and other course materials were sent to participants in advance of the program, many would benefit and perhaps the complaints on course content and emphasis would be reduced (provided, of course, that the title is accurate.)

   Since the present course materials are very useful to some participants, materials supplementary to the lectures and presentations should be continued.

   Engineers who enroll in intensive, highly technical short programs like this one expect and need to receive outlines of the lectures, viewgraphs, and other materials. Without these aids, memory fades fast and the probability of the participants' recalling the information when needed is greatly reduced. Currently, most successful programs offer these.

3. Schedule More Opportunity for Participant Involvement. Since the majority of respondents had used SUPREM and many would welcome an opportunity to discuss their experiences and question the instructors about current developments, changes, future plans, etc., more discussion time should be planned. This might be done by extending the program an extra day or within the one-day format by scheduling discussion periods or question-answer sessions at the same time as some of the research presentations and letting the participants choose which session they wished to attend. As one respondent observed, "An open session involving user interchange and experiential feedback would be most helpful; possibly more so than a yearly update of some of Stanford's other research work."

Also "breaks" of adequate length and lunch periods should be scheduled free of formal presentations to all participants to talk to others and relax a bit.

4. UC Extension should plan additional courses that follow these brief state-of-the-art programs. Perhaps extra sessions the following day in the form of workshops on the computer programs, or a series of short follow-up programs that address some of the course topics in greater depth.

COMPUTER AIDS FOR IC TECHNOLOGY AND DEVICE DESIGN
Course Questionnaire - July 9, 1979

The National Science Foundation has funded U.C.B. Extension to evaluate the quality and usefulness of its engineering short-courses. Your responses to this questionnaire will help us improve our programs.

We appreciate your taking the time to answer these questions.

1. Who initiated your decision to attend this course?

(65%) I did (35%) my superviser (—) I was selected by my company

2. How does your company encourage attendance at course like this?

(98%) pays fees and expenses
(32) gives time off
(—) pays part of expenses
(2) no special support

3. How many people from your company are attending this course?
1 = 20%; 2-4 = 44%; 5-9 = 20%; 10 or more = 16%

4. What is your highest academic degree? Bachelors' = 31%; Masters' = 37% PhD = 32%

When did you receive it? (year)
Range from 1950-1979. Median = 1972

5. What is your job title?

6. What % of your time is spent in:

Average
(10%) Supervision/Administration
(50%) Research
(10%) Production Processes
(-) Other (What?)

7. How many people do you supervise? 0 = 41%; 1 or 2 = 15%; 3-5 = 15%; 6 or more = 29

8.

Av Rank		How well were they achieved? Not at all	Somewhat	Very well
#2	( ) Learning fundamentals	(17)%	(82)%	(5)%
#1	( ) Overview of current research	(2)	(41)	(57)
#3	( ) Learning advanced theory	(16)	(64)	(20)
#4	( ) Solving process problems	(28)	(69)	(3)
	Other (specify) meeting others — learning New Technology	(1)	(—) (1)	(—) —

9. How well prepared were you for this course?
Not at all = 7%; Not very well = 20% Adequately = 28%; Well = 28%, very well = 17%

10. How much would it have helped you if course materials were sent out in advance? Not a bit = 11%; Somewhat = 26%, Good idea = 38%, Very much = 25%

11. Have you taken this course (or one like it) before? Yes = 13% No = 87%
When?
If yes, was there enough new material to keep you interested? out of 7 responses; 4 said "yes"; 3 "no"

12. What specific topics are most related to your work? (CVD, Implantation etc.)
34% said "all".

How long have you been working in this area? average 5 1/2 years
less than 1yr.= 14%; 1yr.= 14%; 2-4 yrs.= 32%; 5-10 yrs.= 20%; >10 = 20%

13. Was the course description stated accurately?
yes = 58% (6 qualified their answer by saying the course title was inaccurate)
no = 42%

14, Was there something you expected to learn, but didnt?
If so, what?
yes = 58%
no = 42%

15. Did you have specific problems you wanted help on? yes = 38%
no = 62%

16. What information will be of most use to you on the job?

	Somewhat	yes	no	Poss.b'y
17. Were you already familiar with SUPREM?	10%	72%	18%	—
Have you used SUPREME?	—	60%	40%	—
Do you plan to use it in the future?	—	80%	12%	8%

18. How useful will the course notes be in your work?
Very much = 29%; Somewhat = 44%
little = 21% Not at all = 6%

19. What topics would you like to have covered in other Extension Courses? See list

20. Where else do you have a chance to learn more about your field?
N = (29) company conferences (27) in-house (9) inter-company
(10) Berkeley (18) Stanford (9) other universities
(7) extension (-) colloquiums (14) grad/undergrad. courses

21. What suggestions do you have for improving this course?

See list

Other remarks:

Return to: Engr. Ext.
U.C. Berkeley
2223 Fulton
Berkeley, CA 94720

The NSF Evaluation Team is planning to arrange follow-up interviews with participants of this course to assess long-term usefulness and job applicability of the information covered in this course. If you are willing to take part in a brief interview, scheduled at your convenience, please fill in your name and phone number below.

Name _____

Phone Home: ( ) Work: ( )

( ) Want further information. ( ) prefer phone interview
( ) Do not want to participate

Responses to Q. 12. What specific topics are most related to your work?

all (12)
CVD Impl. (15)
Laser anneal. (6)
Imp. difusion and oxidation kinetics (5)
Device analysis & process model. (6)
SUPREM & SEDAN (2)
Compu. modeling (2)
EPI & Poly si_1 etching (1)

Responses to Q. 14. Was there something you expected to learn, but didn't?
No- 16; yes-21

More on SUPREM - data on experimental verifcation ; history and status of each user function; update on SUPREM & future plans; what was wrong with present models, etc. (8)
More on process modeling (10)
Less about device design (1)
Solving device characteristics rather than process parameters (1
Detailed device modeling on short-channel MOS (1)
Exact avaialbility of SEDAN, cost, etc.

Responses to Question 15. Did you have specific problems you wanted help on?
yes- 17; no-28 ; n.r.-7

What is punch through preceisely?
Solving device characteristics from process parameters.
2-d bipolar modeling.
laser annealing.
arseniz model in SUPREM
MOS Modeling
Details on SUPREM use (3)
More accurate model in Vt

Replies to Q. 7 What topics would you like to have covered in other Extension Courses?

photolithography (OPT, E-Beam)
failure analysis techniques.
advances in thin SiO_2 film formation methods
high electromigration metalurgical systems
numerical analysis & modeling of semiconductor devices
more detail on device analysis and computer simulation.
modeling
more detail on laser annealing
circuit & logic simulationtechniques. Device modeling for simulation.
device physics fundamentals; cv analysis as an analytical tool.
materials characterization; process induced defects.
derivation and use of SUPREM and new work on device design models.
data base for process modelling.
high speed device (e.g., short channel MOS technology
photovoltaic device technology
etching Si and other materials
each of the specific topics of this seminar could have a course devoted to it.
advanced oxidation theories.
problems and solutions in high surrent ion implementation
problems and solutions in plasma etching.
CAD
more of the same.
experimental verification of SUPREM
Uses of SUPREM and examples. Parts of the program explored in detail.
SEDAN, TANDEM
SUPREM arsenic model, simulating implants through nitride and oxide/nitride layers, epi autodoping model.
two-dimension and one-dimensional field and current distribution modeling. Of major interest to me would be a course on the electrical characteristics of SiO_2 in particular, conduction and charge trapping.
2-d modeling for computerized circuit analysis.
MOS modeling
gettering, high pressure oxidation, enhanced diffusion.
PN junction reverse-bias failure modes: mobile charges, surface states, precipitate emission & gettering, stacking faults.
advanced lithography; plasma processing
the same.
More detail on the TANDEM program.
Scaled MOS
More users information on SUPREM
short channel effects
power MOS overview

Responses to Q. 16. **What information will be of most use to you on the job?**

All the information was helpful (2)
General background info. on IC Tech. (4)
Update on Stanford Research
Recent progress at Staf. ICT Lab. (1)
Update on Stanf. & Hitachin dev. sim. prog. (1)
Cuhlbert (?) research (1)
SUPREM (rel. research) (5)

Laser annealing & oxide info. (5)
Physical mechanisms of prcess steps in SUPREM (1)
Physics & math of device modelling (1)
2-dim. modelling as described in course lit. (1)
Lack of progress in 3-d modelling
Oxid. theory & ion implant- 4
How best to interpret modelling results (1)
or gather correlative data
Good course notes would be (2)
Techniques used by other programs. (1)
Don't know (1)
None (2)

Responses to Question 21:

What suggestions do you have for improving this course?

Replies by Ph.D. Participants:

1. Course Materials:
   --The material handed out and the lecture were completely different. I have yet to use the material. Printed notes would have been a greater help to those attending and added more to the question periods.
   --Provide notes of talks. The information handed out at the conference was largely old. Prof. Dutton did say that course notes would be mailed out. I have not received them.
   --The course materials handed out will be of very little use to me since they didn't reflect the content of the lectures.
   --Hand out course notes of the lectures with good details.
   -- Course materials should be more closely related to the actual lectures.
   -- Make the course materials relate more closely to the talks.
   -- Have the course materials be available to the participants in detail and in advance of the course.
   -- I am deeply disappointed in the fact that the course organizer does not even bother to send a copy of lecture notes to the attendees. I am extremely disturbed because the course notes distributed in the class did not reflect the exact content of the lectures.
   -- Handing out actual lecture notes at the start of the course is a must. This was not done, and much information could not be written down fast enough. The handout was not well related to the lecture material.
   -- Copies of viewgraphs are a must; preferably as handouts before course begins. Lack of the latter was a huge disappointment.

Responses from participants with Master's/Bachelor's Degrees.
   --Send viewgraph copies.
   --Better notes.
   --Handout notes before course.
   -- Copies of the lecturers' notes would be useful during the presentations for better notetaking. Some of the material was presented too quickly for note taking. I have not yet received a copy of the speaker's notes which would be most useful.

2. Course Content and Emphasis:
   -- I would prefer more emphasis on CAD models. This was a very minor part of the program. I had expected more emphasis on CAD models from reading the course brochures, but less than 20% of the class was spent on this.
   -- From the course brochure, I expected something on detailed device modeling of short channel MOS - this was not covered.
   -- As a course it could be better balanced. The content emphasis currently reflects areas of recent Stanford activity. I expected more information on device modelling/simulation from the description in the brochure.
   -- Not enough details on modeling.

Responses to Q. 21 (Cont'd)

-- Go into the actual use of SUPREM such as limitations, tradeoffs, run efficiency, etc. Of course, this could be a course in itself.
-- Should have a good introduction for SUPREM beginner.
-- Cut down on amount of material presented & increase Basic Material Science Content.
-- I think most engineers are interested in availability of models than can be used now (fully realizing that they aren't perfect.)
--I expected more about SUPREM - the history and status of each user function.
-- The subject drifted from computer aids. I expected more information about the availability of SEDAN - cost, inc.
--Follow outline more closely (i.e., content of course should follow initial course description: Expected more about the use of computer model-- how to use SUPREM.
--I liked the course. However, many people with no process background attended this course because of the misleading title. They were not very satisfied. I expected actual program description.
-- I expected more details on the status of modeling research at Stanford and wanted more details on use of SUPREM.
--This was a report by graduate students on SUPREM - not at all like the flyer described. Expected more on MOS modeling.
--Break up course into several parts in order to put greater emphasis on participants' area of interest.
--I thought it was going to be on computer modeling. It was not so much a course as a conference. Course description stated inaccurately.
-- Never use videotape.
-- Expected more descriptive information on device modeling activites.

An open session involving user interchange & experiential feedback would be most helpful; possibly more so than a yearly update of some of Stanford's other research work.

- Overall the course was very worthwhile for me and I am planning to attend next year.
- Course over-emphasized process --device line. Expected more on process relating to device characteristics.

Responses to Q. 21 (Cont'd)

Course content & emphasis

--This was not a course but a forum for S.U. staff to tell us what they were doing and show us how clever they were regardless of course title, needs of attendees, and outrageous fees. I expected to learn about the derivation and use of SUPREM and new work on device design models.
-- I expected to learn how exactly SUPREM & TANDEM work. We need a hands-on demonstration at the computer terminal.
--Have two courses - one general and one advanced for those working in the field of modeling. Make faculty accessible for questions.
--The course title was misleading. Course was mostly about IC Technology and very little about computer modeling of it.
--I would have liked more detailed information on laser annealing.
--How about a course in circuit and logic simulation techniques. Device models for simulation? This course was very well organized and presented.
--I expected to hear less about device design. I'm interested in learning more about the data base for process modeling.
-- I expected more on SUPREM.
-- I was looking forward to more information on the use of computers in IC Tech & D vice Design and wish more emphasis had been placed on that. Overall it was fairly good and broad.
-- I wanted more time to be spent on device modeling and much less time on MOS Processing as was described in the course description.
--Too much for one day; should be a two-day course.

Instructors

--I have no suggestions. Both content and presentations were excellent.
--Eliminate talks like the one B.E. Deal gave.
--Laser annealing would have been more useful had the speaker, Gibbons, attended.
--I expected to learn the latest problems with and update on SUPREM.

EVALUATION OF THE U. C. BERKELEY EXTENSION COURSE "INTERFACING TO A MICROCOMPUTER" (June 18-24, 1979)

Instructors:
Professors David Patterson, Carlo Séquin
Department of Electrical Engineering and Computer Sciences, University of California, Berkeley

Evaluators:
Martha Maxwell, Ph.D.
NSF Project, Director
Rick Boettcher,
Research Assistant

Interfacing to a Microcomputer is a five-day hands-on lab course designed to give participants an overview of the multitude of input/output interfacing techniques and of the hardware/software tradeoffs involved; and the experience necessary to design the microcomputer interface to the real world for their own particular application. Two instructors lectured each morning and the participants spent the afternoons working in the lab. on six experiments with the help of lab. assistants. The following were listed as prerequisites for the course: 1) engineering or scientific background; 2) some programming experience (in any language), and 3) some familiarity with TTL integrated circuits.

This report is based on the responses of twelve participants to a questionnaire given on the last day of class, interviews a month after the course with 4 participants, observations of the class, and discussions with the instructors.

Characteristics of the Students

All students were college graduates. One held a master's degree. They had been out of college an average of 8 years. On the average, they spent 41% of their time on research and development activities, 6 percent on test/quality assurance and 20% on production. Four persons were engaged in other activities including technical writing, software design, administration, and design. About half of the class work in equipment fabrication, 41% design programs and 33% test programs while one-quarter perform all three functions. Fifty percent of the class had no previous experience in interfacing peripheral devices with computer systems and 5 considered themselves well prepared or fairly well prepared for the course. In general the class was somewhat diverse in experience and background ranging from amateurs to those actively working with computers on relevant projects.

Evaluations of the Course

Most of the class were quite well satisfied that the course had offered them a better understanding of micro-devices, a perspective for decision-making, and an opportunity to expand job opportunities. Those who were interested in exploring new career alternatives were somewhat less satisfied.

This project was funded by the National Science Foundation under Grant #SED-78-22138. The opinions, finding, conclusions, and recommendations expressed are those of the authors, and do not necessarily reflect those of the National Science Foundation.

A third of the class expected to learn something different than the course offered - i.e., more details of hardware techniques, more on applications, more comparative data on microcomputers vs available computers.

In general, students were very well satisfied with the course. Those who had taken previous courses rated it as better than other courses they had taken.

The students all rated the instructors as good to excellent, found the lab sessions very helpful, and the lab. assistants excellent. Most students found some topic in the course that they could use immediately and some (about 33%) felt that the topics would be useful in the future. Also they were pleased with the course materials.

Student complaints centered around the problems they had getting the software to work, machine "glitches", etc. Some felt they needed more of a cookbook approach and/or more explanations of computer acronyms.

The following interview summaries illustrate some differences between students, their range of interests, and the applications they plan to make:

Student A is a computer scientists with a BS in engineering who works as an analyst/programmer in biomedical research. He took the course because he is interested in the actual interfacing of hardware. Although he had little background, (none in electrical engineering) he now feels pretty competent about micro-processing and well able to find reference materials. He is taking other graduate courses toward a degree in computer science. He rated the course as the best he has taken and the instructors as excellent and plans to take other courses in extension. He is using the course materials regularly and feels that the course has been particularly valuable to him professionally since he was limited in knowledge about hardware before taking the course. He thinks the CEE courses are somewhat theoretical (or applied at a high level) but that this is good because they are state-of-the-art and offer a quick way of bringing people up to par.

Student B is a systems analyst with a strong background in programming, but little knowledge of hardware. He took the course because he was interested in learning more about hardware and to help him in his project of developing a general purpose modular data access system. He has not used the information learned in the course, but expects to use it and plans to take other courses (provided they don't require a heavy EE background.)

He felt the course had too much information on microprocessor architecture (z-8000) and felt he needed more information on interfacing. He considered the lab. too short and felt much time was wasted on machine "glitches". He stated that he learned quite a bit and rated the course as better than others he had taken. He plans to take additional courses and has had some chance to spread the information to 5 or 6 others in his department.

Student C is a technical writer with a recent Bachelor of Arts degree who took the course to be able to understand operations, to expand her present capabilities and to explore the possibility of going into programming. She felt she knew a fair amount about microprocessors before taking the course, but had no actual experience nor training in computers. After taking the course she felt very well prepared to start learning programming and has since taken a programming course. She feels well prepared for it because she had learned the basics in this microprocessing course.

She feels that taking this course has made her writing more informative and that she is much better able to convey important ideas. She does not feel the need to take more courses in interfacing since she doesn't need to invent or create material -- only to understand it. She rated the instructors as good and the lab. assistants great, but said she needed more of a cookbook set of instructions for the hardware part of the course.

Student D is a design engineer who said he knew a bit about microprocessing, but not a lot before taking the course. He took the course to determine whether the technology would be useful to his company. He has not used the material because his company is not in a position to use microprocessing as yet. He feels his knowledge about the subject doubled as a result of taking the course, and that the instructors and lab. assistants were excellent. He rated the course as very good and feels the information he learned will be beneficial to him in the future.

Summary and Recommendations

Although this class varied in their expertise and sophistication with computers, the students all gained something they wanted from the course and considered the course successful. They were pleased with all aspects of the course -- the lectures, labs., instructors, and assistants. The small size of the class and the intensive personalized attention given in the labs. made it possible for individuals to learn what they needed.

The recommendations suggested are to find ways to resolve the difficulties with the soft-ware (or to help students accept these difficulties as inevitable); and perhaps provide those who are unfamiliar with the computer terminology a glossary of terms and acronyms.

INTERFACING TO A MICROCOMPUTER
Course Questionnaire
June 24, 1979

N = 12

The National Science Foundation has funded U.C. Berkeley Extension to evaluate the quality and usefulness of its short courses for engineers. Your responses to this questionnaire will help us improve our courses and develop an evaluation model for other courses.

We appreciate your taking the time to answer these questions.

1-4. What is your highest academic degree? year graduated?

BA/BS = 11 MS = 1 average 8 yrs. out of school

5-12. What percentage of your work involves:

	%
(41)	R&D
(6)	Test/Quality Assurance
(20)	Production
(23)	Other (What?)

13. Do you:

	%
(42)	design programs
(50)	fabricate equipment
(33)	test programs
all (25)	

14. Are you primarily a:

	#
(2)	supervisor
(0)	research associate
(5)	engineer
(2)	technician
(3)	other (what?)

15. How many people do you supervise?

$\bar{x} = 3.5$

16. How much opportunity is there for you to disseminate the information you learned in this course to others in your company?

2.8 (1-4 range)

17. How much experience did you have in interfacing peripheral devices with computer systems before taking this course?

6 (or 50%) none 2 or very little 2 fairly 1 more than average

18. How well prepared were you for this course?

not sufficiently - 1, some amateur 3, fairly well 2 (had taken other courses)
1 in hardware 2 very well 1 don't know

19. In your opinion were the course prerequisites stated accurately?

yes = 8 2 = no (probably should have had 8080 lang. & experience

2 = don't know or no opinion

20-8. What were your goals in taking this course? (Rank order using #1 as the most important, 2 as next, etc.	$\bar{x}$	How well were they achieved? (Check from very well to not at all.) Not at all				Very Well	$\bar{x}$
(8) acquiring a perspective for decision-making	4.1	(0)	(0)	(3)	(3)	(4)	4.1
(8) expanding job capabilities	3.7	(1)	(0)	(2)	(5)	(2)	
(10) getting a better understanding of micro-devices	4.2	(0)	(0)	(1)	(7)	(3)	
(6) exploring a new career alternative	3.3	(1)	(0)	(2)	(2)	(1)	
(1) Other (what?) interface to real world					(1)		

29. Was there something you expected to learn in this course, but didn't?

If so, what? 4 yes 7 no

30-38. What topics in the course will be of most use to you on the job? Either immediately or in the long run?

	of immediate use	useful in the future
Program Operations	3	4
Interfacing with Imput & Output Devices	9	1
Data handling capabilities	3	4
Microprocessor operations (8080 chips)	5	4

(On the reverse side of this page please describe the ideas & techniques you found most helpful and how you will use them.)

See comments

39. How did this course compare with other short courses you have taken?

%	
(20)	the best I have taken
(50)	better than others I have taken
(-)	about the same as others
(-)	less satisfactory than others
(30)	have taken no others

Interfacing to a Microcomputer,

40. Please comment on the following aspects of the course:

Instructors	
Lectures	Comments ranged from "good" to "excellent" (see list attached)
Lab. sessions	
Lab. experiments	
Lab. assistants	

41. How useful will the text and course materials be in your work?

see comments

42. What suggestions do you have for improving the course?

see comments

43. Are there other courses that you'd be interested in taking?

see comments

The NSF Evaluation Project Team is planning to conduct case-studies on engineers who have taken short-courses. If you are willing to participate in two brief interviews, to be scheduled at your convenience, and to permit us to interview your colleagues and supervisor, please fill in your name and phone number below.

Name_____ Phone #_____ _____ _____
(area code)

(6) prefer telephone interview (1) want further information
(6) do not want to participate

STUDENTS WRITTEN COMMENTS ON QUESTIONS

Q. 29. Was there something you expected to learn in this course, but didn't? If so, what?

Yes = 4

(2) More comparison information to help choose a specific mp like 6502 vs 6800 vs 8080. PDP, HP 300, etc.

(1) More on applications on processes are suitable for.
(1) Details of hardware techniques.

No = 7

Q. 30-38 Which techniques and ideas did you find most helpful and how will you use them?

-a general understanding of computer architecture and the capabilities of mp.
-details of machine language and assg. language programing- the power of the instruction set.
-details of how performance will increase in the next few years.
-1/o techniques necessary to interface thru ports/a keyboard, CRT, and TTY with a 6502 mp.

Q. 40 Comments on aspects of course:

Instructors:

The hardware instructor made his material very clear, however I found it difficult to leap around as much as the instructor in software although the material is more familiar to me than hardware.

Instructors and lectures were good, but labs. weren't covered enough in class.

Instructors were excellent and lectures very good.

Instructors were knowledgeable and answered questions thoroughly so that the student could understand. They were good.

Lectures were well organized and understandable.

Instructors were very good to excellent - clear and logical. The lectures were good, of necessity skimming & fast.

Instructors were excellent and very good. Lectures were good, but fast.

Instructors were excellent; material well organized and presented to coincide with experiments. Lectures could have included a little more detail re 8080 instructions.

Instructors and lectures were both good.
Instructors and lectures were both very good.

Students Written Comments on Questions

Q. 40. Lab. Sessions & Experiments:

-quite good (1)

-needed more time to do out-of-class work/perform experiments. (2)

-Lab. assts enthusiastic

-all very good / helpful (8)

-excellent (1)

-need better introduction to the H.P. terminal 8080, material should be condensed, i.e. exactly does a certain O.S. subroutine do? Lab. assistants were very good.

-Experiments were well designed, but had too many problems with the equipment.

-Experiments were well chosen and of progressive difficulty.

-Could not have completed labs. without the lab. asst's help.

-Lab. sessions acceptable. as were the lab. experiments.

-Lab. sessions were a good learning experience. Experiments were challenging, but good. Some frustration with the reliability of equipment.

-Needed more guidance, perhaps in the form of an actual demonstration prior to each experiment might have been useful. They were enjoyable experiments, however more cookbook instructions (particularly for hardware) would be useful.

-Lab assts. were great! Very helpful, knowledgeable & encouraging.

-Labs had too little guidance relative to what peripheral equipment was doing (What was in the "black box"?)

Q. 41. How useful will the text and course materials be in your work?

probably useful
very useful - it gives me a solid background for understanding
good
unknown
very useful. The text can well be used as a reference aid as it is well organized and indexed.
Will use it as a lst reference.
Text will be helpful.
Some
very useful for reference.

Q. 42. What suggestions do you have for improving the course?

-Discussion of some specific areas where mp are being used and the advantages gained.

-Better lab. equipment, list of specific "tricks" needed to get software to work - more consistency between actual hardware and documentation.

Students Written Comments on Questions,

Q. 42. (continued)

-none

-More guidance in lab., perhaps in the form of an actual demonstration prior to each experiment might have been useful. They were enjoyable experiments, but more cookbook instructions (particularly for hardware) would be useful.

In describing periphery chips, etc., explain some of the acronyms used in computer science.

Q. 43. Are there other courses that you'd be interested in taking?

programming microprocessors
yes- unspecified
compilers/would like to receive notices of future courses.
don't know of any others.
not at present.